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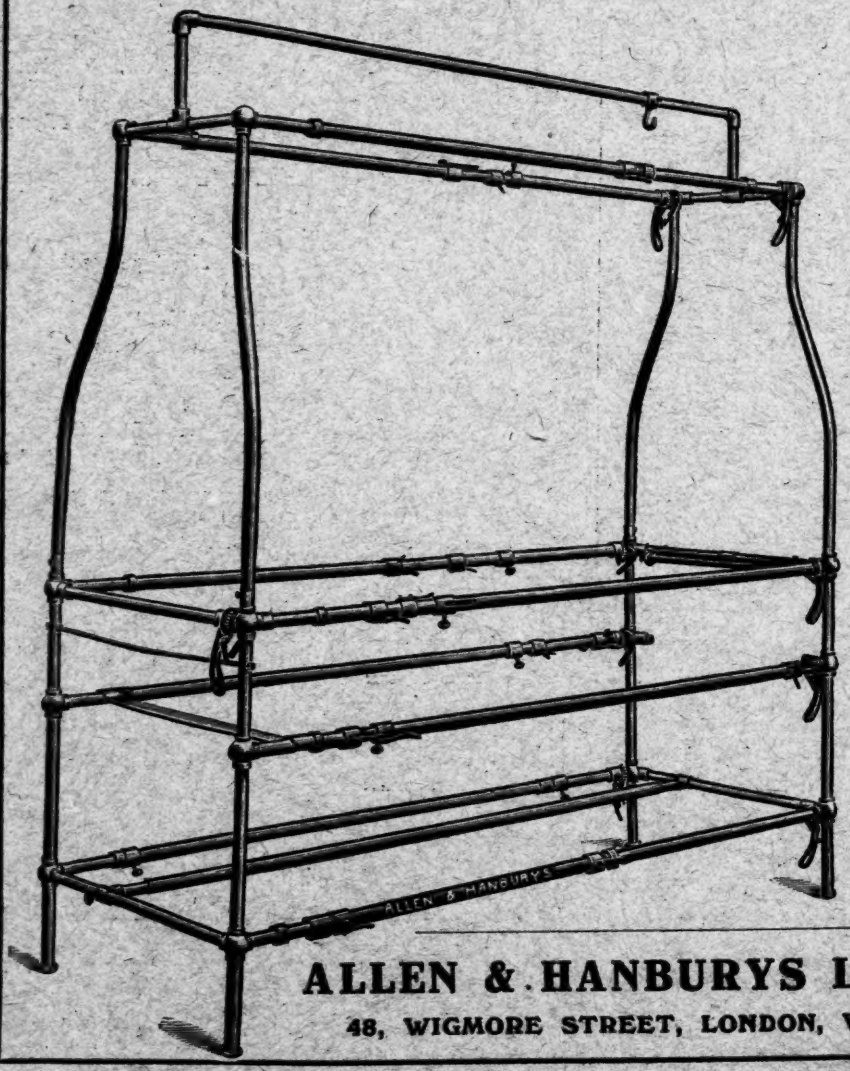

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ROBERT LISTON.

1794–1847.

ROBERT LISTON was born on October 28, 1794, in the manse at Ecclesmachan in Linlithgowshire, the eldest son of Henry Liston, whose father and grandfather had also been ministers of the church in Scotland. His father was a writer on music, the inventor of the euharmonic organ, designed to give the diatonic scales in perfect tune, and an improver of the plough; he also published selections from Horace and the sixth book of Cæsar, for the use of schools. A brother—David—became Professor of Oriental Languages at Edinburgh.

Robert Liston was educated by his father, and having entered the University of Edinburgh in 1808, was awarded the prize for Latin prose composition at the end of his second session. In 1810 he began to attend the lectures of Dr. John Barclay, a well-known extra-academical lecturer on anatomy and physiology, who soon afterwards appointed him as his assistant and prosector, a post he retained until 1815. From 1814 to 1816 he acted as 'surgeon's clerk,' or house surgeon, at the Royal Infirmary, first to George Bell and afterwards to Dr. Gillespie.

In 1816 he visited London, and put himself under Sir William and Mr. Thomas Blizard at the London Hospital, and attended the lectures of Mr. Abernethy at St. Bartholomew's Hospital. At the end of the year he was admitted a member of the Royal College of Surgeons in London. He then returned to Edinburgh, and taught anatomy in conjunction with James Syme, his junior, who afterwards became his successful rival From 1818 to 1828 he worked hard in Edinburgh, and built up for himself a good reputation as a teacher and as a surgeon. Cases which had been considered incurable by the surgeons of the Royal Infirmary fell into his hands on their discharge, and were operated upon by him with success. He was even said to have inveigled patients out of the Infirmary for that purpose, but this charge he stoutly denied. His methods and success caused feelings to run high amongst the surgeons in Edinburgh; no one would assist at his operations, and the managers of the Infirmary actually proposed to him that he should refuse assistance to any person who had been a patient in that institution, and that he should abstain from visiting or attending the wards. He declined to give such an undertaking; and he was thereupon formally expelled, and never entered the gates of the institution for a period of five years. In 1827 he was suddenly elected one of the surgeons by the exercise of private influence, and in the following year he was made the operating surgeon. In 1833 James Syme, his younger rival and former colleague, with whom he had quarrelled, was chosen Professor of Clinical Surgery, and in the following year Liston was invited to become one of the surgeons to the newly-formed hospital attached to the London University, now University College Hospital. He came to London, and was appointed Professor of Clinical Surgery in the University of London.

For some time his professional prospects seemed so doubtful that he thought of migrating to the United States; but practice came, and on the death of Sir Anthony Carlisle in 1840 he was nominated a member of the Council of the College of Surgeons, and in 1846 was elected a member of the Court of Examiners. In 1841 he became a Fellow of the Royal Society. His surgical practice soon became extensive; but in the spring of 1847 he began to suffer from signs of some obscure illness, which ended on December 7 in the rupture of a thoracic aneurysm. He died in Clifford

Street, in the house afterwards occupied by Sir William Bowman, and was buried in Highgate Cemetery.

Liston's claim to remembrance lies in the boldness of his operations, assisted by his sound knowledge of surgical anatomy, which enabled him to operate successfully in cases from which other surgeons shrank. Living at a time immediately antecedent to the introduction of anæsthetics, he attained a dexterity in the use of cutting instruments which had probably never been equalled, and is unlikely to be surpassed. When chloroform was unknown, speed was of the utmost importance in the performance of a surgical operation, as it saved pain to the patient and anxiety to the surgeon. "Who that once saw Liston perform a capital operation could ever forget it?" asks one of his pupils. "The manner in which he handled the knife had in it something remarkable. It at once put the spectators at their ease, and convinced them that the instrument would not go anywhere or do anything but what it ought. He possessed a confidence and self-possession that no untoward event ever disturbed; a readiness in suddenly applying expedients that seemed to the inexperienced the result of forethought; and a power in his muscular arms and bony hands that enabled him to twist, depress, or elevate parts with an ease that appeared almost magical. As a lithotomist he excelled, and his flap amputations were performed with such rapidity that the sound of sawing seemed to succeed immediately the first flash of the knife. With him the length of operations was estimated by seconds instead of minutes, and the student who unwarily turned his head to address his neighbour, on looking round often discovered that what he had struggled so much to witness had already been performed. Yet in all this there was no real hurry; it was the result of a skilful combination of movements performed with precision and exactitude." These very qualities occasionally led him to disaster, as when he opened an aneurysm instead of an abscess with one bold sweep of his knife, or undertook the removal of inoperable tumours, disasters which his numerous enemies were only too glad to magnify.

Liston, with the help of William Cadge, afterwards of Norwich, performed the first operation under ether in Europe, on December 21, 1846. The patient was a man suffering from a septic arthritis of the knee. The thigh was amputated in twenty-five seconds, and the patient left University College Hospital cured on February 11, 1847.

Liston lived at a time when professional rivalry only too often degenerated into personal abuse, and hatred reached bounds of which the present generation has no conception. Rough and ready, his manner towards his inferiors and those who differed from him was often most offensive, and his language was so coarse as to be often brutal. Many stories are told of his rudeness, and of the retorts to which he thereby laid himself open. After an altercation with Syme, whose head he had publicly compared to the skull of an ape, his coachman asked, "Where to, sir?" as he got into his carriage. "To the devil," said Liston. "Does His Majesty want an operation?" quietly asked the man. Yet, withal, Liston was generous-hearted, and some at least of his quarrels were made up before he died. A man of great stature and strength, he rode often to hounds, and had a yacht on the lower reaches of the Thames, for he had wished to follow the sea before his attention was turned to surgery.

Liston had no claim to the title of a scientific surgeon; he was not a good speaker, nor was he very clear as a writer. He published two books which ran through more than one edition, *Elements of Surgery*, in 1831, and *Practical Surgery*, in 1837. His efforts were directed towards the simplification of methods. In the treatment of wounds he was opposed to the method of occlusion then in common use, and advocated delayed suture of amputation flaps and a water dressing. This practice continued long after his death, and was at length replaced by the principles enunciated by Lister. In like manner, he taught that a fractured thigh should be kept straight instead of with the limb bent, as was then usual. "Some prejudice," he says, "has

ROBERT LISTON.

From a chalk drawing now in the possession of Mr. Raymond Johnson, F.R.C.S. Eng., to whom it was given by Sir John Eric Erichsen.

always existed against the straight position of fractures, as it is thought that certain muscles must act so as to pull the ends asunder. In trying to humour one set of muscles, however, others are necessarily put upon the stretch and excited, whilst in the extended position it is found that all become quiet very shortly, and the ends of the bones fall into their natural position." To secure this end he evolved the splint still known by his name, to replace the cumbersome apparatus devised by Desault, Boyer Stanley, and Hagedorn. The splint still retains vestigia of its original use in the digitate lower end and the two holes in the upper extremity, for Liston obtained extension and counter-extension by the splint itself, and made no use of the weight of the patient, as was done afterwards. Liston also appears to have invented the bone-cutting forceps, with one surface flat and the other bevelled, which is still in common use.

The illustration is made from a chalk drawing in the possession of Mr. Raymond Johnson, F.R.C.S. Eng., to whom it was given by the late Sir John Eric Erichsen, Bart.

ON CANCER OF THE TONGUE: THE BRADSHAW LECTURE, 1918.*

By D'ARCY POWER, London.

Mr. President and Gentlemen,

It was, I think, a wise latitude on the part of Mrs. Bradshaw when she founded this lecture in the year 1882 in memory of her husband—Dr. William Wood Bradshaw, M.A. Oxon., D.C.L.—to lay down no limitations as to its scope. It was to be a lecture on Surgery, and it is thus left to each lecturer to choose his own subject.

When the President invited me to undertake this honourable duty, I hesitated to accept, because in the hurry of these latter days it is difficult to find time for the original research which can alone render it of permanent value. I reflected, however, that you had recently nominated me to serve as one of your representatives on the Executive Committee of the Imperial Cancer Research Fund, and this gave me an opportunity of dealing with a topic which embraces the clinical and scientific sides of that dreadful disease. I have therefore chosen for your consideration this afternoon the subject of 'Cancer of the Tongue,' one of the most distressing forms of cancer which afflicts the human race. I have done so the more willingly because it brings into close relationship the historical, clinical, and scientific sides of inquiry, and it seems to me that these three lines must be closely followed if any satisfactory conclusion is to be arrived at.

PECULIARITIES OF CANCER OF THE TONGUE.

Cancer of the tongue, as is well known, presents several peculiarities which make it worthy of careful consideration. In the first place, it is almost entirely a human disease, and this is remarkable, because the tongues of many animals are more liable to injury than is the human tongue. Secondly, cancer of the tongue is always primary, and is always of one type—a squamous-celled carcinoma. This is noteworthy, because the tongue of all animals contains many varieties of epithelium, any one of which might be expected to undergo malignant change as easily as the squamous epithelium. Cancer of the tongue is unknown in children; it is rare in young people; becomes frequent between the ages of forty and sixty; and, until lately, it has diminished in frequency in extreme old age. It is common in men; rare in women. Moreover, it does not run the same course in men as in women: in men, it generally ends in death within eighteen months of the onset; in women, it appears more often to run an erratic course. I shall presently mention the cases of women in whom recurrence took place with such rapidity, after a complete operation by a competent surgeon, that nothing more could be done three weeks later, and of others whose sufferings were mercifully ended by death after eighty-four months and one hundred and eight months respectively of constant pain. Lastly, the inherited predisposition to cancer which is thought to be a feature in some forms of carcinoma seems to be nearly absent in cancer of the tongue. Each of these peculiarities is deserving of more careful consideration than it has hitherto received, for each must be due to some discoverable cause. I propose therefore to offer a few suggestions which may be interesting to you and serviceable to those who choose to work further upon the subject.

---

* Delivered at the Royal College of Surgeons of England, November 14, 1918.

I. HISTORICAL.

I will deal first with the historical side, and in doing so I find a virgin page in the history of medicine. No one, so far, has made any attempt to write about the literary history of surgical disease, though such a study would be of great interest and value. Such a history would be easier to write than that of medical complaints, because visible pathological conditions are more readily observed than those which are hidden.

The classical writers were well acquainted with cancer of the breast, of the uterus, of the penis, and of other parts of the body. From Hippocrates downwards, they give directions for the treatment of these diseases either by medical or surgical means, and state when they may and when they may not be removed. Cancer of the tongue, at any rate in its later stages, is no more difficult to recognize than epithelioma of the penis; yet Dr. E. T. Withington, who is making a special study of the old Greek writers for a new edition of Liddell and Scott's *Lexicon*, tells me that he has noticed a curious absence of any direct mention of cancer of the tongue in the Greek medical writers. The twelfth section of the second book of the *Prorrheticon** contains an injunction to examine the teeth in cases of chronic ulcer on the side of the tongue. The passage immediately preceding it treats of the deep and superficial *καρκίνοι* occurring in elderly persons, and it looks therefore as if the writer thought that chronic ulcers of the tongue might sometimes be of this nature, but did not like to say so definitely.

Galen (b. A.D. 131) describes functional disorders of the tongue, but says that he purposely omits organic diseases because he is considering them elsewhere. This treatise, unfortunately, has not come down to us.†

Oribasius (A.D. 326–403) in his *Synopsis* has a chapter on 'Malignant Ulcers,' where he mentions cancer and malignant ulcers of the pudenda, testes, and breasts. He also has a chapter on cancer of the vulva, which he says is incurable, and gives some methods of relieving the pain, but gives no hint of any similar affection of the tongue. It is probable, therefore, that he was unfamiliar with cancer of the tongue, and had never seen a case.‡

In like manner Rufus, commenting on Oribasius (45, ii), gives a detailed account of the different forms of carcinomata and their usual localities, but omits all mention of the tongue.

Rhazes (A.D. 850–923 ?), says nothing about 'apostema durum' when enumerating the different forms of 'apostema' which occur in the tongue.

Avicenna (A.D. 980–1037), in his *Canon of Medicine*, devotes a long chapter to the tongue. He may have obtained his account of the 'apostema durum' and cancer of the tongue from the lost treatise of Galen. At any rate he mentions cancer as distinct from 'apostema durum.' It is possible, therefore, that he had seen or heard of a case, but he gives no detailed description of one.§

Arnold of Villanova (A.D. 1238–1314), who was an epitome of the medical knowledge of the school of Salerno, wrote a chapter on 'Ulcers and Pustules of the Tongue,' but without mentioning any condition which can at all be described as cancer.

Bernard Gordon (fl. 1285), his contemporary, devoted a long chapter to 'Diseases of the Tongue' in his *Lily of Medicine*. He there speaks of 'ulcera maligna,' but states that

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* HIPPOCRATES, *Opera*, Genevæ, 1657, p. 96 E.

† The tongue, he says, is liable to "inflammationes, tumores duri, tumores molles, erysipelata, suppurationes, de his vero, utpote quae tum visu tum tactu discerni possunt, nihil aliud in hisce commentariis dicemus, quippe eas duntaxat affectas partes hoc in libro prosequi proposuimus." (*Galeni Opera*, Basil, 1549, vol. iv; *De Locis Affectis*, Liber iv, cap. ii, p. 88 C.

‡ The passages occur in the *Synopseos*. Under 'De Ulceribus Malignis,' he mentions "medicamenta ad carcinode, malignaque ulcera, ad pudendorum, testium et mammarum inflammationes." (Liber vii, cap. xi.) A little farther on is the chapter 'De Cancro Vulvae,' of which he says, "Hic morbus curationem non recipit."

§ AVICENNA, *Canon*, Liber iii, fen. vi, cap. 14, 'De Apostematibus Linguae.' "Quandoque accidunt linguae apostemata calida, et apostemata phlegmatica, et apostemata ventosa, et apostemata dura, et cancer. Et signa omnium illorum manifesta erunt cum redierint ad illud quod dictum est in signis apostematum."

they are seen chiefly in children, and are easily cured by simple remedies. In all probability, therefore, they were aphthous ulcers.

William de Salicet (fl. 1245), Lanfrank (d. 1306), Henri de Mondeville (1260–1320), Jan Yperman (1275–1330), Gui de Chauliac (d. 1368), and John Arderne (1307–1390), all writers of the great surgical text-books of the thirteenth and fourteenth centuries, neither mention cancer of the tongue, nor do they describe any condition which in the least resembles it.

John of Vigo (1460–1517), with his keen surgical instinct, and Fernelius (1497–1558), who wrote on *Universal Medicine and Pathology*, would certainly have alluded to the condition had it been of frequent occurrence in their practice. Both are silent.

Riverius (1589–1655) devoted the fifth book of his *Praxis Medica* entirely to diseases of the tongue. The first edition was published in 1640, and he there says expressly, "Tumours of the tongue do not for the most part endanger life unless they grow so large as to cause suffocation, or come from a certain malignant or melancholic humour, when a cancerous swelling may be produced which is known by its hardness, blueness, and pricking pain."* It would seem from this passage that Riverius had actually seen cancer of the tongue, but it is noteworthy that he gives no details of any case in the volume which he published containing accounts of the many patients who had been under his care during his long and busy life.

The first definite notice of cancer of the tongue which I have been able to find is in English. It occurs in *The Chirurgicall Lectures of Tumours and Ulcers*, which were given by Dr. Alexander Read to our predecessors, the United Company of Barber Surgeons, in their Hall in Monkwell Street, on Tuesdays in 1635. Dr. Read says,† "It falleth out sometimes that sores in this member (the tongue) prove maligne and very fretting, as it happened to the late Lord Mayor of London, Ralph Freeman. Hee lacked neither Physitians nor Physicke, yet old age, weaknesse and the malignitie of the sore hindered the procuring of his health, which his Physitians and Chirurgeans aimed at and wished for. The ulcer was so corrosive that it fretted asunder the veines and arteries of the tongue on that side which it possessed and caused a great flux of blood which exceedingly weakned him, for that present causing a strong syncope, so that afterward nature could not re-collect her selfe. When such griefes befall great personages their case is worse than that of the poorest in the like infirmities, because Physitians and Chirurgians are not permitted to use the like libertie in the application of medicaments to the one as to the other. If the like case fall out hereafter at any time, I advise you to use medicaments borrowed of the vegetables so that you contemne not the minerals. What hurt I pray you can come from the use of Merc. Dulcis and Merc. præcipitat. with gold? None I assure you; for these medicaments are familiar to nature and are true balsams for maligne sores.

"But you may aske what was the reason these medicaments were not used? I answer, because there was no mention made of these medicaments at the first, and it was too late to minister them at the last, nature being surprised: for this only would have made the medicaments odious, and the Physitian (who should have advised this course) obnoxious to calumnie and reproach."

Ralph Freeman died on March 16, 1633–4, during his year of office as Lord Mayor of London, evidently from secondary hæmorrhage due to cancer of the tongue. Dr. Read wished to administer mercury, but was overruled. It is possible, therefore, that he thought an antisyphilitic course might have been useful; on the other hand, mercurius dulcis, which was the precursor of calomel, was just coming into vogue, and was being employed in every form of inflammation by those advanced physicians who had adopted

---

* "Tumores linguae ut plurimum vitae periculum non afferunt nisi in tantam molem excreverint ut inde suffocatio metuenda sit, aut ex humore quodam maligno atque atrabiliario ortum duxerint unde cancrosus tumor generari potest quod duritie, lividitate, ac dolore pungitivo internoscitur."

† "*The Chirurgicall Lectures of Tumors and Ulcers*, delivered on Tusedayes appointed for these exercises and keeping of their Courts in the Chirurgeans Hall these three yeeres last past viz. 1632, 1633 and 1634. Lond. 4to. 1635." Treat. 2, lect. 26, p. 313.

the new chemical pharmacy then replacing the treatment by herbs which had been in use from time immemorial.

It is interesting that this first record of a case of cancer of the tongue which I have been able to discover should have been presented just two hundred and eighty-four years ago to an audience similar to that which I am now addressing—the Master, Wardens, and Members of the United Company of Barbers and Surgeons: the only difference being that attendance on Dr. Read's lecture was compulsory, the attendance here to-day is voluntary. At that time it was enacted that "every man of the Company useing the mystery and facultye of surgery—be he freman, fforeyn or alian straunger—shall come unto the lecture, being by the Beadle warned thereto. And for not keepinge their houre both in the forenoone and also in the afternoone and being a ffreman shall forfayt and paye at every tyme iiiid."

From the middle of the seventeenth century onwards, cancer of the tongue was a well-recognized surgical disease in England, for Wiseman and other writers on surgery make frequent mention of it, and were devising methods for its cure.

It was, however, still rare in Germany, for Paul de Sorbait published a case in 1672. "We saw," he says, "an ulcer [of the tongue] degenerating into cancer in the case of the noble Baron Vertemali, which caused such a hæmorrhage from destruction of the sublingual arteries and veins that the patient was suffocated. He recognized with great penitence that the cause of this cancer was a divine punishment because he had often abused the clergy." *

Bonetus (1620–1689), writing on the tongue and its diseases thirteen years later, seems to have been unable to find another case—unless, indeed, he wished to point a moral—for he quotes the same case with some elaboration of details. "There was lately," he says, "a certain Baron who had a very poisonous tongue. He not only directed his jibes against all and sundry, but kept his most venomous shafts for the clergy and those who devoted themselves to God's service. He was caught at last in the very act when he was pealing this cursed bell, by a holy brother of good repute, who said to him, 'Your foul tongue has overlong deserved that punishment from an offended God which it will shortly receive.' The Baron went off undismayed, but a few days afterwards a small swelling began to grow on the side of his tongue. Little by little it increased in size until it became an inoperable cancer, and at length, the tongue having become incurved, twisted, and drawn back to the fauces, miserably afflicted, but penitent and confessed, he was summoned before the Great Judge who calls his servants to a most strict account." †

I think from the historical side it is fair to assume that cancer of the tongue has always existed; that during the classical and mediæval periods it was so rare as hardly to merit attention by the ordinary writers on surgery; in the seventeenth century it became common; and, as I shall show presently, its frequency is still increasing.

During the sixteenth century, therefore, something occurred to increase the frequency of cancer of the tongue; and three causes at once suggest themselves, for they were new factors, and greatly influenced the social life of the time—syphilis, tobacco, and the consumption of alcohol in the form of spirits. Of syphilis I shall speak in greater detail presently.

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* *Universa Medicina*, Tract. I, cap. 34. "Vidimus in Illustrissimo Barone de Vertemali, utpote qui, in cancrum degenerans, corrosis sublingualibus venis et arteriis, hæmorrhagiam tantam excitavit, ut ea suffocatus fuerit Aeger. Causam hujus cancri, summa ductus pœnitentia, agnovit ipse divinam, eo quod Religiosis graviter et frequenter detraxisset."

† "Nuper quidam Baro in more habuit venenatissima Linguae jacula, non tantum in quemlibet sed maxime in Deo devotos religiosos frequentissime jaculari; in flagranti a pio honestæque vitae religioso deprehensus fuit, cum infernale hoc pulsaret tintinnabulum; ad quem religiosus ait, quam maledicta tua lingua jamdudum meruit poenam ex justa Dei vindicta intra breve tempus experietur. Relicto et minime commoto Barone, elapsis paucis diebus Tumor exiguus ad Linguae latera pullulare coepit, qui paulatim crescens carcinomatis inexpugnabilis naturam manifestavit, a quo tandem incurvata, convulsa et retracta ad fauces lingua, miserrime delictum, poenitenter confessus ad strictissimum Judicem suorum famulorum vindicem acerrimum, commigravit. (*Medicina Septentriolanus Collatitia*, 1685, vol. i, p. 302. The case is headed 'Tumor Linguae Miraculosus.')

Tobacco, as is well known, was brought from Cuba by the Spaniards in 1497, and under the name of Petum was introduced into Europe on account of its medicinal properties. Inhalation of the smoke was also learnt from the Indians, but it was not until 1586 that Ralph Lane brought the implements and materials for smoking into England, although a few persons had acquired the habit as early as 1573. It quickly took root amongst the Elizabethan courtiers, the pipes being short and made at first of silver and afterwards of clay, as is known from the pipes and pipe-cases belonging to Sir Walter Raleigh, which are still preserved in the Wallace Collection at Hertford House.

The poor at this time were content with a walnut-shell and a straw. One pipe often sufficed them for a smoking party, the pipe being handed round the table at threepence a pipeful. It is hardly surprising that sore tongues increased rapidly in number. Syphilis at the same time was rife, and the older treatment by mercury was beginning to give place to guaiacum and other less reliable remedies. Syphilis of the tongue, both as a primary lesion and as a late glossitis, soon became well-known to the medical profession.

The practice of smoking was at first essentially English, but it quickly spread to the north of Europe, being probably introduced by our sailors. King James I tried to stop the habit, and in 1604 issued his *Counterblaste to Tobacco*, in which he says that smoking is "A Custome loathsome to the Eye, hatefull to the Nose, harmefull to the braine, dangerous to the lungs, and in the black-stinking fume thereof neerest resembling the horrible Stigian smoke of the pit that is bottomlesse." The *Counterblaste* was useless; but although the custom was well established in London, it took a long time to spread through the country, and as late as 1665 it was noted as something unusual that 'such an one was a smoker of tobacco.'

Alcohol.—It is often said that alcohol in the form of spirits plays some part in the production of cancer of the tongue, but history does not appear to show any close interrelation between spirit drinking and lingual carcinoma. During the seventeenth century social habits remained very much as they had always been. In London, breakfast was not usually eaten, but a piece of bread with a draught of wine or a cup of beer was taken at a tavern some time in the morning. Dinner was the chief meal of the day, and taverns were used for that purpose nearly as often as we now go to restaurants. The fare was simple but ample, and although men were often "scandalously overserved with liquor," it was usually with wine or beer. Spirits, in the form of Scotch whiskey or French aqua vitæ, were esteemed as early as the sixteenth century, but they were not much drunk until the reign of Elizabeth, nor was any excise duty imposed until 1684, and in that year it was only levied upon a little more than half a million gallons.

Habits changed quickly after the introduction of coffee. Men became interested in learning the news, and frequented the coffee-houses. Coffee-houses in turn gave place to social clubs, where, in place of coffee, a bottle of wine or a bowl of punch became the popular beverage, and the use of spirits thus increased so enormously that during the years 1721–91 the consumption of British spirits alone reached an average of 0·62 gallon per head of the population, an amount which did not include foreign and colonial spirits. The eighteenth century was a jovial, sociable, hard-living age, when men drank spirits freely, kept extraordinarily late hours, and yet were obliged to take much physical exercise owing to the poor facilities for travelling both in town and country. Cancer of the tongue increased in frequency during this period, but not out of proportion, so far as can be ascertained. It seems probable, therefore, that spirit drinking is not an important factor in its causation. During the whole of this period syphilis continued unabated, but it was treated so severely by salivation and diet that many died of the cure.

II. ZOOLOGICAL DISTRIBUTION.

Cancer, as is well known, occurs in many vertebrate animals, from mammals to fish. Its zoological distribution has been the subject of more than one interesting contribution to the reports of the scientific investigations of the Imperial Cancer Research Fund. The types of carcinoma do not differ materially in human beings and in animals, when similar organs are affected.

I have made enquiries of my friend Sir John M'Fadyean, the Principal of the Royal Veterinary College, and of Dr. J. A. Murray, Director of the Imperial Cancer Research Fund, as to the frequency with which cancer of the tongue occurs in animals. Sir John M'Fadyean has had especial facilities for gaining knowledge of this nature, because he asked in 1890 that veterinary surgeons, stockowners, and others would send him all tumours excised by them in order that he might collect information regarding the occurrence of cancer in domesticated animals. The appeal brought him a considerable number of specimens, and he writes to me in 1918, twenty-eight years after this appeal was issued: "In 1890 I published in the *Journal of Comparative Pathology* an account of a case of cancer of the tongue in a cat. It was the first case I had seen in any animal, and since then I have only seen one other case, and that was in the tongue of a horse. The tumour in the horse had been diagnosed during life as one of actinomycosis, but the appearance of the tongue after death was different from actinomycosis as seen in the tongue of cattle, and microscopical examination showed that the case was one of quite typical epithelioma."

The details of Sir John M'Fadyean's first case are as follows: "*Carcinoma of a Cat's Tongue.*—The tumour grew on the tongue of a cat, and was handed to me by Professor Walley. The cat was a male, and aged twelve years. It had been ill for about two months prior to the date at which it was killed, the symptoms observed being discharge of saliva with occasional streaks of blood, difficulty of mastication and deglutition, and progressive emaciation. Microscopical examination showed that the tumour was composed essentially of masses of epithelium burrowing along the lymphatic spaces of the tongue. The epithelium resembled pretty closely that of the deepest layer of the buccal mucous membrane. Each cell had a large nucleus and a deeply staining (carmine) nucleolus. The central cells in the larger masses of epithelium had undergone a colloid degeneration, probably in consequence of defective nutritive supply." *

In like manner, Dr. Murray writes: "I can only recollect two cases of squamous-celled carcinoma linguæ in animals in our material, both in cats."

In 1902 Dr. Anton Sticker published a very elaborate paper 'Ueber den Krebs der Thiere,' † in which he analyzed the occurrence of cancer in 215,037 horses, 5795 cattle, 91,273 dogs, 1732 cats, and many pigs. In this vast collection, cancer of the tongue only occurred in one old dog.

The net result, therefore, is that one horse, three aged cats, and one old dog are known to have died of cancer of the tongue, and in each case it was a squamous-celled carcinoma. Nothing is known of the previous history of these animals.

These figures show that cancer of the tongue occurs in domesticated animals, but so rarely that it is negligible, and that when it occurs it is of the squamous-celled variety, just as it is in the human. It seems fair to assume that cancer of the tongue in domesticated animals at the present time has not increased in frequency, but remains the same as it has always been; and, as I have already said, history appears to show that until the seventeenth century cancer of the tongue was as infrequent in men as it now is in animals.

III. STATISTICAL.

Leaving now the historical and scientific sides of the question, and turning to the statistical aspect, Dr. T. H. C. Stevenson, superintendent of statistics at the Central Register Office, Somerset House, tells me that cancer of the tongue had already attracted the attention of the Registrar-General as early as 1909, when he wrote, "The increase amongst males from cancer of the jaw and especially of the tongue is remarkable, and can scarcely be explained by improved diagnosis. Although cancer of the tongue in its later stages presents little difficulty in diagnosis, the recorded mortality has increased amongst

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* *Journal of Comparative Pathology and Therapeutics*, 1890, vol. iii, p. 41; with an illustration of the microscopic appearances.

† *Arch. f. klin. Chir. von Langenbeck*, Bd. 56, 1902, pp. 616, 1023, and 1067.

males by no less than 228 per cent in 41 years. The increase, moreover, is entirely confined to the male sex."* This remarkable statement is based upon the following figures, which show the annual death-rate per million living, 35 years of age and upwards :—

	1868	1888	1909
Males	46·49	77·49	152·54
Females	17·45	12·46	14·97

The increase in the death-rate from cancer of the tongue continued to increase, until in 1915 it had more than trebled since 1868. There was still no material increase for women, and amongst men the increase was chiefly at the higher ages, that is to say, from 65 years upwards. Thus, the mortality between the ages of 65 and 75 was 283 in 1901, and 432 in 1916; between 75 and 85 it was 284 in 1901, and 420 in 1916; whilst in persons over 85 it was 166 in 1901, and no less than 516 in 1916.

It is a pity that statistics of death from cancer of the tongue are not available before 1868, but Dr. Charles Singer has done something to remedy the omission. He states† that "the death registers referring to the Chelsea Hospital for old soldiers have been examined from the years 1837 to 1910, and among 4,719 deaths of pensioners of the age of 55 and upwards, at least 62 were certified as due to oral cancer. Of these 62, at least 28 were carcinomata of the tongue and floor of the mouth, giving the proportion of deaths due to the last two causes as 6 per 1000."

An examination of the blue-books issued by the General Registrar shows that of the deaths of males over 55 years of age registered in England and Wales during the years 1901–1909, only 3·5 per 1000 deaths were due to cancer of the tongue. Thus, even with the imperfect certification and greater statistical rarity of carcinoma in earlier years, cancer of the tongue appears to have been twice as common among this group of old soldiers as among the general population of comparable age in Britain to-day.

It should be remembered that the pensioners in this series were long-service men, and that, in the earlier years at least, many of them must have been serving in 1817, at a time when Thomas Rose,‡ surgeon to the Coldstream Guards, had nearly persuaded the Army that syphilis could be cured without mercury, a heresy which was supported by Guthrie,§ but was not shared by the soldiers themselves, many of whom bought Liq. Hyd. Perchlor. privately, and thereby made the fortune of a druggist living near their barracks.

Some additional facts can be gleaned from the reports of the Registrar-General.‖ Here is a table showing the ages at which death occurred from cancer of the tongue during the years 1901–1909 in 6257 men and 782 women :—

Age at Death	Males	Females
Under 5 years ..	0	1
„ 10 „ ..	1	0
„ 15 „ ..	1	0
„ 20 „ ..	2	3
„ 25 „ ..	33	53
„ 35 „ ..	427	85
„ 45 „ ..	1626	128
„ 55 „ ..	2143	167
„ 65 „ ..	1485	209
„ 75 „ ..	498	121
85 and upwards ..	41	15
Totals ..	6257	782

* Seventy-second Annual Report, p. xciii.

† *The Quarterly Journal of Medicine*, 1911, vol. v, p. 20.

‡ *Medico-Chir. Trans.*, vol. viii, p. 346.

§ *Ibid.*, p. 545.

‖ Seventy-second Annual Report, pp. lxxxii–lxxxv.

This table shows that the true proportion of males to females affected with cancer of the tongue is 8 to 1. Our hospital statistics give a proportion of 18 to 1; Sir Henry Butlin thought it was 6 to 1. The table also shows that at that time the optimum, or shall I not rather say the pessimum, age for cancer of the tongue is 55–65 in males, and 65–75 in females. The table, to be strictly accurate, should be headed 'Cases of Malignant Disease of the Tongue,' because the two or three cases occurring in very young persons are almost certainly sarcomata and not carcinomata.

The difference in the death-rates of males and females has already been noticed by Dr. Charles Singer, who plotted it out in curves on the accompanying chart (*Chart* 1) which he has kindly allowed me to reproduce from his article, 'A Study of some Factors in the Ætiology of Oral Carcinoma.'* He says, "The death-rate presented by cancer of

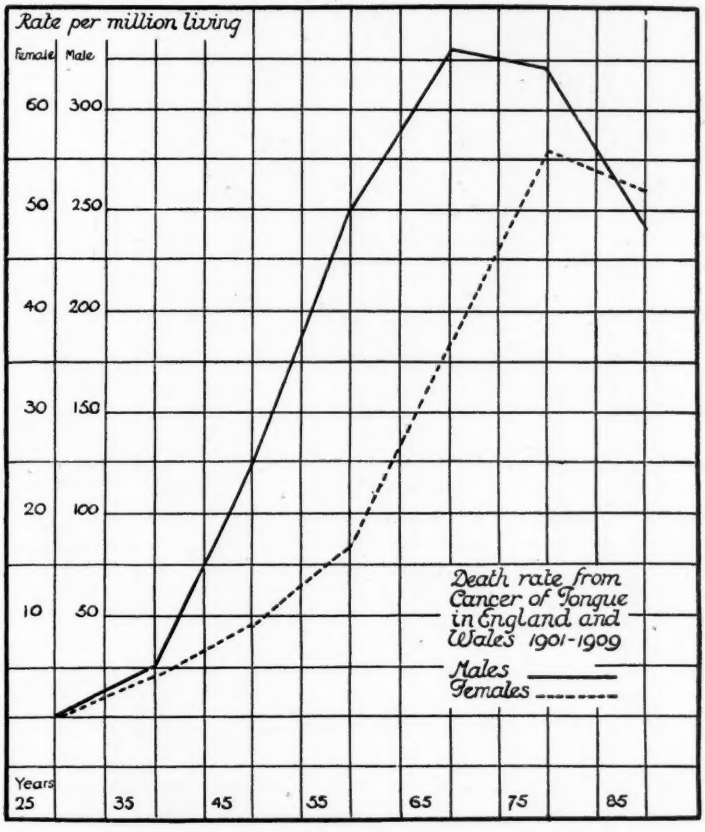

CHART 1.

the tongue has certain peculiarities which are not shared by that of cancer of other parts of the body. It differs, in the first place, from the death-rate from malignant disease of those other parts of the body in which a liability is shared by both sexes, in the marked differences in character of the age incidence of males and of females (*Chart* 1). The death-rate from cancer of the tongue in males rises steadily until about the sixty-fifth year, when the rate remains almost uniform for two decades, to fall again in extreme old age. In the female cases the death-rate rises slowly at first, and by no means parallel to the male; then, becoming accelerated about the sixtieth year, it rises rapidly to a maximum at or about the eightieth year, and again falls slightly (though less than the male curve) at the extreme limit of life.

* *The Quarterly Journal of Medicine*, 1911, vol. v, p. 22.

"The chart illustrating the death-rate from lingual cancer thus presents the following characteristic features: (*a*) The dissimilarity of the male and female curves; (*b*) The approximately equal rates for males in the decades 65–75 and 75–85; (*c*) The drop in extreme old age in both sexes. As regards the general form of the curves presented by this group of cases, it may be said that, while the male curve is a type of its own, the female curve accords fairly well with those for cancer of several other parts of the body, and is, for example, closely similar to the curve for cancer of the rectum in either sex (*Chart* 2)".

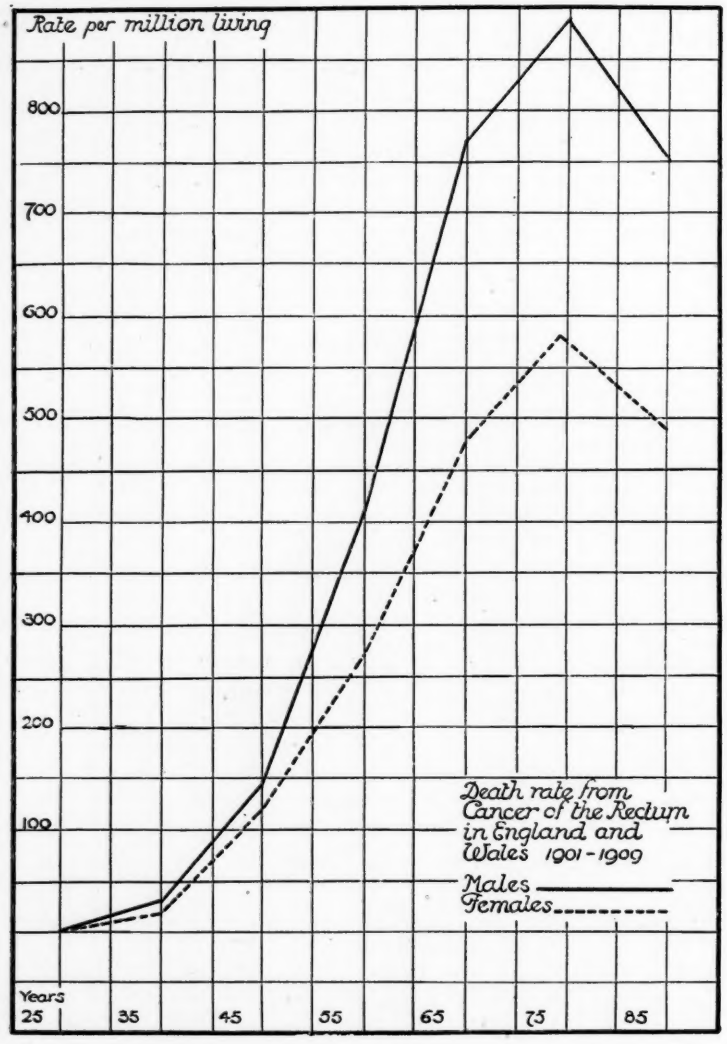

CHART 2.

IV. POSSIBLE FACTORS CAUSING THE INCREASE IN CANCER OF THE TONGUE.

It is clear from the historical and statistical evidence that cancer of the tongue is increasing in frequency, and at the present time it is increasing more rapidly in men than in women. It is of interest, therefore, to try and discover some of the factors which have caused this increase. Irritation is thought to be an important factor in the causation of cancer, and I have therefore been at some pains to ascertain whether the state of the teeth has altered materially since cancer of the tongue became rife, because many patients state that injury to the tongue by a tooth was the origin of the cancer.

a. **Pyorrhœa Alveolaris vel Periodontitis.**—Pyorrhœa is widely distributed throughout the human race, and is often met with in animals under domestication, as well as in wild animals kept in captivity. The animals which have been most carefully observed in regard to pyorrhœa are the horse, the cat, and the dog—the three animals in which cancer of the tongue has occasionally occurred.

Amongst 600 horses working in London, it was found that approximately one-third presented some degree of periodontal disease, mainly of local origin and the result of injury to the mucoperiosteum by foreign bodies in the diet.

Periodontal disease is also extremely prevalent in domestic cats and dogs. It is most frequent in highly-bred cats, because they are fed on soft food, whilst the ordinary domestic cat, which has to get its own living and feeds upon a meat diet, is comparatively free. The same holds true for dogs. Pyorrhœa is seen most commonly in lapdogs and dogs with short muzzles, and especially in the functionless incisor teeth of bulldogs. Dogs living on a good flesh diet which gives plenty of exercise to the jaws are invariably free from the disease. It is clear, therefore, that whilst pyorrhœa may act as a source of irritation to the tongue, it is only of minor importance in producing cancer, as otherwise cats and dogs should be affected much more often than is actually the case.

b. **Caries.**—Caries of the teeth, in like manner, seems to be only of slight importance as a factor in causing cancer of the tongue, although it is often put forward prominently as an exciting cause.

Dental surgeons have done much good work in determining the existence of caries in the teeth of different races from prehistoric times to our day. The late Mr. Mummery examined over 3000 skulls to determine the prevalence of dental caries, and tabulated the results of 1658 cases. Caries occurs from the earliest times, varying in frequency in different districts. Among 68 skulls obtained from Wiltshire barrows, there was only a single case of decay; whilst in 44 skulls from similar long barrows in the more northern parts of England, there were 9 cases of caries.

During the bronze age caries was more frequent, for there were 7 instances in 32 skulls, whilst in the Yorkshiremen of this period there were no less than 26 cases of caries in the 60 skulls examined.

During the Roman period the teeth were often diseased, and in 143 Roman skulls 41 were thus affected, the amount of caries in some individuals being very great; thus, in one woman, aged about thirty, every molar and every bicuspid was diseased. If such a large proportion of Romans in Britain suffered from caries, there is no reason to suppose that the Romans at home were exempt; and if dental caries and stumps were an important cause of cancer of the tongue, it must certainly have attracted the attention of the classical writers on surgery. Yet Celsus, in speaking of ulcers of the tongue, contents himself with following the statement in the *Prorrheticon* of Hippocrates, saying, "Those on the side of the tongue last a very long time, and it should be noticed whether there is a sharp tooth, for this often prevents healing and may need filing." *

In Anglo-Saxon times the proportion of teeth affected with caries was certainly less than in Roman times, and Mr. Mummery states that he only met with it in 12 out of 76 Anglo-Saxon skulls. We have no knowledge of the incidence of dental caries in England from the time of the Conquest until the beginning of the seventeenth century. Mr. J. F. Colyer has now taken up the investigation, and has been examining skulls obtained from the Clare Market district in the immediate neighbourhood of this college. Large numbers of Londoners were buried in the graveyard which occupied this site between the years 1600 and 1800. He tells me that 3443 teeth were present in the skulls which he examined, and 319 of these were carious, the percentage of carious teeth being therefore 9·2 per cent, as against 28 per cent in the Romano-British period. In the skulls and mandibles examined by Mr. Colyer, 669 teeth had been lost from

* Linguæ ulcera . . . quæ in latera ejus nascuntur diutissime durant. Videndumque est num contra dens aliquis acutior sit, qui sanescere sæpe ulcus in eo loco non sinit; ideoque limandus est. Celsus, *Medicinæ*, Lib. vi, cap. xii.

disease. If these specimens are examined more in detail, "we find in the complete dentures 1683 teeth were present, of which 68 were carious, or just over 4 per cent, while in the incomplete dentures there were 1760 teeth present, of which 251 were carious, that is 14·2 per cent. In the latter group 669 teeth were missing, and of these it would be a generous estimate to assume that half were lost from caries, and the other half from periodontal disease. If the estimated carious teeth be added to the known carious teeth, the figures would indicate about one-third carious."

It seems, therefore, as though the proportion of carious teeth amongst modern Londoners is about the same as in Romano-British times. A fallacy lies in the smallness of the numbers under consideration; but if it be assumed for the sake of argument that they are substantially correct, the conclusion must be drawn that, whilst the number of cases of caries has not increased, there has been a very rapid increase in cases of cancer of the tongue. Caries, therefore, is not an important factor in causing lingual carcinoma.

c. **Syphilis and Tobacco.**—None of the factors so far enumerated exercises a preponderating influence upon the increase of cancer of the tongue. It remains, therefore, to consider in somewhat greater detail the two factors pointed out by the history of the disease—syphilis and tobacco.

I have recently examined the records of patients admitted into St. Bartholomew's Hospital suffering from cancer of the tongue during the years 1909–1916. During that period 169 persons entered the Hospital with this disease. Most of them submitted to operation, a few were inoperable, and some discharged themselves after a preliminary examination. The diagnosis of 'squamous-celled carcinoma' was verified in every case operated upon, by an independent microscopical examination carried out in the Pathological Institute attached to the Hospital.

Women.—Of the patients, 9 were women, and 160 men. The proportion of women to men, therefore, was nearly one to eighteen, which, as I have already said, is much smaller than the true proportion as shown—by the returns of the Registrar-General—viz., one woman to eight men.

Seven of the nine women were married, one was unmarried, and the social state of the other is not given. Of the seven married women, one gave a history of syphilis; two had healed syphilitic scars on the body; one was a widow who had only one child alive out of a family of five—the note adds "she looks as if she drank;" one had suffered from leucoplakia of the tongue from the age of 17, and stated that her father had suffered from "an abscess of the brain," of which he was cured by medicine—this was probably a gummatous meningitis, the patient herself being the subject of inherited syphilis; there was no history of syphilis, either acquired or inherited, in the other two married women. The unmarried woman, a nurse aged 42, said that her father died of aneurysm, and that one sister had cancer of the breast. The patient herself, during the same month in which she first noticed the ulcer on her tongue, found that her right eye was fixed in such a manner that she could not turn it outwards—abducent paralysis. This affection of the eye was cured by medicine, and was probably syphilitic in origin.

All the women had bad teeth, and attributed the cancer of the tongue to irritation caused either by the teeth or by a badly-fitting or broken denture. None of them smoked. In none of these cases was a Wassermann test done.

The duration of the disease had varied greatly in these women. In one, a woman of 52, the cancer grew so rapidly that the tongue was removed three weeks after the first occurrence of symptoms; whilst in another patient the tongue had been painful for eleven years before an operation was considered necessary.

There was also an interesting case which may be mentioned here, though it does not belong to the series, as it was under the care of Sir Henry Butlin. The patient was a married woman, age 24, with pyorrhœa. She was admitted to the hospital with a cancer of the tongue dating, as she said, from the irritation of a carious tooth in May, 1898. Sir Henry Butlin removed her tongue on Dec. 9, 1898. She was discharged from the hospital on Jan. 7, 1899, and returned on Jan. 23 of the same year—i.e., only sixteen

days later—with such extensive recurrence that no farther operation could be undertaken. This woman had suffered repeatedly from small ulcers of the tongue before the cancerous ulcer was observed. These ulcers had appeared in crops three or four at a time, but were curable. The case is remarkable, both on account of the youth of the patient and the rapidity of recurrence after removal of the tongue by a surgeon who was especially careful not to do things by halves.

Men.—The men admitted with cancer of the tongue presented some additional and noteworthy points. Their teeth were nearly always bad, but not worse than is usual in the class to which they belong. Many were edentulous, some from age, some because they had their teeth removed after the appearance of the ulcer for which they sought advice. Of the 160 patients, 93, that is to say 58·5 per cent, were syphilitic. Of the 93, 62 gave a history of syphilis, and the remaining 31 showed signs of syphilis in the form of chronic glossitis, aortic disease, scars of healed ulcers, tabes, etc. The syphilis was invariably of long standing and, taking a few cases in the series without selection, the primary infection was said to have been 26 years, 30 years, 29 years, 40 years, 28 years, 23 years, and 43 years previously. Twenty-six of the patients stated definitely that they had never contracted syphilis, but of these one had suffered from gonorrhœa, and two had a positive Wassermann test. Many of the patients had drunk beer to excess, but did not as a rule acknowledge that they had taken spirits freely. There is no doubt, however, that many were, or had been, alcoholic. For instance, one was a farmer who stated that he took thirty glasses of strong beer daily and smoked continuously; he had cancer of the tongue which was removed at the age of 74. Another man, who said that he smoked eighty cigarettes a day, was usually drunk six days a week, and had contracted syphilis twenty years previously, suffered from a richly deserved cancer of the tongue at the age of 42. On the other hand, a teetotaller and non-smoker, who denied that he had ever suffered from syphilis, had his tongue removed for carcinoma at the age of 51.

A Wassermann test was performed 26 times, with the result that in 12 cases it was negative, in 6 positive, in 5 it was doubtfully negative, and in 3 doubtfully positive. These results may be compared with those obtained by Captain Arnold Renshaw, Demonstrator of Pathology at the Manchester University Medical School (who wrote to me at the kind request of Dr. C. H. Browning, Director of the Bland-Sutton Institute of Pathology, Middlesex Hospital), and by Captain Archibald Leitch, Pathologist to the Cancer Hospital, Brompton. Captain Renshaw writes: "Seventeen cases of squamous-celled carcinoma of the tongue were examined, and only two cases showed a positive Wassermann reaction. Two of the negative cases gave negative reactions before and after (twenty-four hours before and forty-eight hours after) an intravenous injection of neosalvarsan, this being repeated in each case after a second injection had been given. In one of these cases there was a definite history of syphilis twenty-five years previously." Captain Leitch writes: "I regret that I cannot give you any definite figures. All I can say is that the majority of cases I tested gave a positive reaction. The numbers tested were comparatively few, merely sufficient to establish in my own mind the fact that the result of a Wassermann reaction was of no service whatever in assisting a diagnosis between syphilis of the tongue and carcinoma of the tongue. Of that I am certain. Strangely enough, I did a few reactions in advanced lingual syphilis, and some of these were quite negative." Carl Bruck* says that he obtained ten positive Wassermann tests in twelve cases of leucoplakia of the tongue.

The Wassermann results are interesting, but too much importance must not be attached to them as signs of active syphilis, because, as Lieutenant-Colonel L. W. Harrison wisely says,† "Although the Wassermann test looks deeper into the patient's condition than the naked eye, it is not an absolute guide to a decision regarding the absence of syphilis."

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* *Die Serodiagnose der Syphilis*, Berlin, 1909, p. 70.

† *The Diagnosis and Treatment of Venereal Diseases in General Practice.* The Oxford Medical Publications, 1918, p. 280.

As regards the influence of syphilis upon cancer of the tongue, the number of cases under review is too small to generalize upon, and is only useful to point out the direction in which future work is advisable. There is, moreover, a possible fallacy. It is a matter of common belief that syphilis is in some way associated with cancer of the tongue. Every patient, therefore, is asked as a matter of routine whether or not he has previously suffered from syphilis. This is not done in other surgical diseases, and there is consequently no means of determining what proportion of patients admitted into hospital would acknowledge previous syphilitic infection.

It is not uncommon in a family for two or more members of the same generation to suffer from lingual carcinoma, but it is very rare for a father and son to die of the disease. There is one case in the records at St. Bartholomew's Hospital, but I can find no other. This may mean that the son, born whilst the father has active syphilis, is thereby protected if he does not happen to have leucoplakia; or it may imply that the tissue changes in the tongue which are sufficient predisposing causes in the first generation are compensated in the second generation. The first assumption is the less likely, because inherited syphilis, as has been shown, is actually a factor in cancer of the tongue. The point is in need of further investigation, first as to whether it is a fact, and secondly as to the explanation. Another point for investigation is to determine whether cancer of the tongue occurs more frequently in syphilized members of families predisposed to cancer than in those with no such history. Personally I do not believe that it does.

The evidence seems to point at present to a close association between syphilis and cancer of the tongue. The syphilis may be active; it is more often quiescent or even extinct. It may be inherited; it is more often acquired. In every case the syphilitic infection has preceded the appearance of cancer by very many years, and the preliminary syphilitic changes therefore are slow and prolonged. Of these preliminary changes I know nothing. I have examined many sections of cancerous tongues, but there are no constant histological changes in the deeper tissues which are attributable to the effects of spirochætal infection. Tongues which were leucoplakic at the time of removal show a thickening and fibrosis of the walls of the arterioles, but in others there was no manifest change either in the blood-vessels, the lymphatics, or the connective tissue. An examination for such changes needs more care, a larger amount of material, and much more prolonged study than I have been able to give in the limited time at my disposal. All that can be said at present is that syphilis in some way alters the resisting power of the epithelium of the tongue, and allows the squamous cells to run riot; in other words, that lingual carcinoma is born on the bed prepared by syphilis. A similar relationship has long been known to exist between syphilis and tubercle, but in tuberculosis there is a definite infective agent; as yet there is no proof of any such exciting cause in cancer.

When mercury fell into temporary disrepute in the treatment of syphilis at the end of the sixteenth century, and again in the Army at the beginning of the nineteenth century, it seems that cancer of the tongue increased in frequency. It would be interesting to determine whether the present increase can be associated with the very imperfect treatment of syphilis which was in vogue during the mid-Victorian period. The sound teaching of John Pearson (1758–1826), surgeon to the Lock Hospital, that mercury in sufficient doses was the proper treatment for syphilis,* regulated the practice of most surgeons during the earlier decades of the last century. The introduction of potassium iodide, and its obvious utility in the later stages of syphilis, led to the very imperfect mercurial treatment which continued until our own day. Several of the patients who were treated for syphilis at St. Bartholomew's Hospital, and were admitted for cancer of the tongue forty and fifty years afterwards, stated that they had been given mercury for a fortnight or three weeks only. As late as 1880 the old dread of salivation still lingered, and it was quite usual in the out-patient room to hear a patient protest that he would not take mercury on any account. The treatment at that time was merely a treatment of

* *Observations on the Effect of Various Articles of the Materia Medica in the Cure of Lues Venerea.* London, 1800.

symptoms, and minute doses of the red and green iodides of mercury were frequently prescribed. Is the present great increase in cancer of the tongue amongst old syphilitic patients the aftermath of this treatment?

But if syphilis is a predisposing cause of cancer of the tongue, the exciting cause must be looked for elsewhere, and it ought to be some form of long-continued local irritation. The provocative irritation is sometimes, but not so often as might be expected, syphilitic—the fissures and abrasions of chronic glossitis or the soreness of leucoplakia. Pyorrhœa and carious teeth, as I have shown, are very frequently associated with cancer of the tongue; but had there been no previous syphilis, lingual carcinoma should not have occurred in men and women more often than in the domesticated animals, whose teeth are equally affected by disease. Pyorrhœa and caries are at least as frequent in women as in men, and it is probable that syphilis is just as common, yet cancer of the tongue in women has not yet increased in the same ratio as in men.

It remains, therefore, to inquire whether any change has taken place in the habits of men within the last fifty years which has not affected women to the same extent.

Before 1868, anyone who looks at the pictures in *Punch* will see that snuff-taking was on the wane, and that whilst cigars might be smoked openly in the streets, pipes were taboo in public, and cigarettes were unknown except to foreigners, and travellers who had learnt to smoke them on the Continent or in America. Smoking after dinner was not usual amongst gentlemen who still drank a glass or two of port wine, and in the various Senior Common Rooms to which I was hospitably invited at Oxford during the years 1874–80, the Fellows of the older school only smoked after going to their own rooms. On the other hand, long clay or churchwarden pipes, with a mug of home-brewed beer, solaced the leisure of many country parsons and doctors at the bowling greens and quoit grounds in summer, and round the hearth in winter. The labourer smoked a short clay or cutty as a matter of course. On the whole the upper classes smoked a great deal less than they do at present, whilst the lower classes smoked about the same, but in a more irritating manner so far as the tongue was concerned. From 1877 onwards the smoking of cigarettes has become an ever increasing habit, until now it is well-nigh universal amongst men, women, and boys.

Amongst the patients suffering from cancer of the tongue admitted into St. Bartholomew's Hospital whose cases I analyzed, 37 men stated they had been great smokers, whilst only 2 were non-smokers. It seems possible, therefore, that smoking acts as the exciting cause of cancer in a tongue which has been sufficiently prepared by previous syphilitic infection of the tissues. Smoking acts as an irritant in two ways. My friends have kindly experimented for me, as I do not myself smoke, and they tell me that it causes a definite rise of temperature in the mouth, registerable by the thermometer; and there is also the irritant action of the nicotine itself. Smoking may thus bear the same relation to the production of lingual carcinoma as the brazier does to Kangri cancer.

To sum up, then, I think the following conclusions can be safely arrived at from the evidence I have obtained. Cancer of the tongue has always existed both in men and in animals, the actual cause being as yet unknown. Its rapid increase in men within historical times is the result of two causes: the first predisposing, the second the exciting.

The predisposing cause is the degenerative change taking place as a result of spirochætal infection, the change being accentuated by lapse of years and by indulgence in alcohol. The form in which the alcohol is taken does not seem to be important; beer, spirits, and wine are equally harmful. It is the amount consumed, not the quality, which matters.

The exciting cause is local irritation. The most effective local irritant is tobacco, although pyorrhœa and carious teeth often act as minor exciting causes. The exciting causes may act for long periods of time, but will not produce cancer, except in the rarest instances, without the long-continued action of the predisposing cause—syphilis. The occasional occurrence of cancer of the tongue in animals and in non-syphilized people shows that, as in cancer generally, there is a *tertium quid* as yet undiscovered, which is

called for convenience the predisposition to cancer. This predisposition manifests itself in the varying resistance to cancer shown by different persons. Sometimes the course of the disease is rapid, and an accidental injury to the tongue is quickly followed by a carcinomatous ulcer; at other times, when every factor seems to be present and the individual ought to have cancer of the tongue, he lives to a good old age, and dies of some wholly different disease.

It is this *tertium quid* which we should seek, by correlating, as I have tried to do this afternoon, historical, clinical, and pathological results; for it is only by a wide survey on all sides that it is possible to discover where experimental research is likely to be most useful. Years ago* I carried out a series of experiments to ascertain whether irritation by itself had any influence in producing cancer in animals; but the results were uniformly negative, and some other factor was clearly necessary to make the epithelial cells change their natural method of growth.

CONCLUSION AND FORECAST.

In conclusion, some points of great practical importance are obtainable from what has been stated.

In the first place, it ought to be possible to reduce cancer of the tongue to the subordinate position which it occupied before the seventeenth century in men, and which it still holds amongst the domesticated animals.

At the present time syphilis is more prevalent than it has been for many years, and the consumption of tobacco has risen from seven and a half million pounds in 1914 to eight and a half million pounds in 1915. Much of this tobacco is smoked in the form of cigarettes, and women now smoke on a much larger scale than they used to do. It follows, therefore, that if matters are allowed to continue as they are doing, there will be a huge increase in the number of patients suffering from cancer of the tongue. The increase should begin about 1950, and it should affect women as well as men.

Such an increase can be prevented by a thorough and systematic treatment of syphilis in its initial stages; for, as has been shown, cancer of the tongue has always increased in frequency some years after syphilis has been treated inadequately. Persons who are being treated for syphilis, therefore, should be told never to smoke, not to drink to excess, and to pay regular visits to a dentist in order that their teeth may be kept in the best possible state, and that any dentures they may have to wear should be maintained well-fitting and free from rough edges.

Such advice should be given whilst the patient is actually under treatment for syphilis. It is useless to defer it until the tongue has become sore, because it is then too late in a large number of instances. Many patients, of course, will say that they would rather run the risk of having cancer of the tongue than put up with such a restriction as is involved in renouncing tobacco. It may be so; but at any rate it is our duty to put the matter plainly before them, and to point out the risk they run, in the hope that a few will take advice and be saved from a painful disease and a miserable death.

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* *The Journal of Pathology and Bacteriology*, 1898, vol. iv, p. 69.

TREATMENT OF CASES OF FRACTURED FEMUR AT A BASE HOSPITAL IN FRANCE.

By Lieutenant-Colonel VICTOR HURLEY, C.M.G., A.A.M.C., Melbourne, and Major S. H. WEEDON, A.A.M.C., Sydney.

GENERAL OBSERVATIONS.

In the following paper an outline is given of the methods used and the conclusions arrived at in the treatment of 170 cases of fracture of the femur during the six months July to December, 1917. As these cases have been retained under treatment until firm union has occurred, they have been of special interest, in that the results of treatment have been observed in a manner not possible in other war wounds. It has thus been possible to arrive at definite conclusions on the relative merits of different methods of treatment. At the outset, the necessity of specially staffed and equipped wards was recognized as essential, and three such femur wards, with a total capacity of 100 beds, have been in use

Fig. 303.—A special femur ward.

for the greater part of the above period. The wards (*Fig.* 303) were selected so as to be in the same block of buildings and on the same ground level as the operating theatre and the *x*-ray department. The woodwork and ward fittings were constructed by the hospital carpenters, and for many articles of equipment and furniture in these wards the hospital is greatly indebted to the Australian Red Cross Society.

In most of the cases Thomas knee-splints have been used, together with many added devices and appliances, such as foot-pieces, suspension apparatus, etc. Many of these have been adopted from the work of other surgeons, particularly that of Major M. Sinclair,

to whom we are also indebted for much valuable information and advice. Others of the appliances are original as far as we know, and have been found of practical use.

In order that a connected account may be obtained, we propose to outline the treatment employed from the time of the patient's admission until the time of his transfer to England.

CONDITION OF THE PATIENT ON ADMISSION.

The length of time between the receipt of the wound and the patient's admission to the base hospital varies from 36 hours to 7 days. Most of the cases are admitted on the third and fourth days. The condition of the patient on admission, and his subsequent progress, are greatly influenced by the time which has elapsed before the first thorough surgical treatment of his injuries. Almost all have been thus dealt with at a casualty clearing station, where the fracture has been splinted, usually on a straight Thomas splint. The treatment at the various casualty clearing stations has not been uniform; but in almost all excision of the wound has been performed with varying completeness; we have noted in our later cases that wounds have been more thoroughly excised than in the earlier ones.

The after-progress of the cases has not satisfied us that the more recently introduced antiseptic lotions and pastes possess any superiority over ordinary soap and water or saline. As a general rule, the least satisfactory cases are those in which ineffective excision of the wound has been performed (and in this we include the wound in the bone), one or other of the antiseptics in vogue at the moment has been applied, and the wound completely sutured without adequate drainage. Conversely, the cases which do best are those in which the wounds have been most thoroughly excised and adequate drainage provided. The importance of these primary surgical principles appears to have been temporarily lost sight of in the search for an ideal solution or paste—which cannot be expected to compensate for or correct faulty surgical technique.

Wounds caused by fragments of shell or bomb (and especially aeroplane bombs) are usually more severely infected than are bullet or shrapnel wounds.

Of the total mortality, 38 per cent occurred within forty-eight hours of admission. Shock, gas gangrene, and complications due to wounds elsewhere, were the most frequent causes of death during this period. In several, the patient's general condition on admission would not permit any further operative interference, and nothing beyond restorative treatment was possible.

TREATMENT ON ADMISSION.

General.—Patients are usually admitted in the late evening or night, and are given a hot meal, after which they generally obtain a sound sleep. The patient is left till the following day on the splint applied at the casualty clearing station, unless there are urgent reasons for operative interference, of which gas infection is the most frequent. The soiled wound dressings are of course removed, the wounds inspected and cleaned, and fresh dressings applied. Where Carrel tubes have been inserted, two-hourly instillation of eusol or Dakin's solution is continued. The improvement in the patient's general condition following a good night's rest, after a fatiguing and often very painful railway journey, is usually marked.

X-Ray Examination. — On the following morning stereoscopic skiagrams of the fracture are taken, and where possible (as in fractures of the middle and lower third) direct lateral views also. In cases in which B.I.P.P. has been applied, the finer points of detail of the fracture, fragments, and foreign bodies are greatly obscured. Examination of the stereoscopic skiagrams by means of a Mackenzie-Davidson viewing apparatus usually shows that the fracture requires further treatment to correct displacement of the fragments; and it has been our experience that correct alinement can rarely be obtained on a straight Thomas splint, although this is much the best for purposes of transport.

Portable X-ray Apparatus.—In our earlier cases it was necessary to take the patient

to the *x*-ray department; but later the hospital was supplied with a portable *x*-ray apparatus. This not only obviates moving the patient, but is essential to obtain the best results. When a patient is taken to the *x*-ray department, his suspension and extension arrangements must be dismantled, and the resulting skiagram is practically useless for affording reliable information as to the exact position of his fracture with these in position. During the after-treatment, skiagrams taken with the patient lying in bed, with his suspension and extension apparatus undisturbed, give full information of the exact condition and position at the site of fracture in a way which cannot be ascertained by other methods of examination, however carefully carried out. As will be described in dealing with the ward after-treatment, the later adjustments required to correct accurately the smaller degrees of displacement are carried out and checked in the light of the information obtained from a study of the ward *x*-ray photograph, repeated as many times as necessary.

When should a General Anæsthetic be Administered?—With the information afforded by the *x* rays, together with the result of examination of the wounds and the general condition of the patient, one is able to decide whether a general anæsthetic is necessary. Repeated anæsthetics react unfavourably on the general condition, and should be dispensed with if it is possible to correct the fracture equally well without their use and without causing undue pain. A little more patience is required of the surgeon, and manipulations must be carried out with the utmost gentleness. The unfavourable action of general anæsthetics is particularly noticeable in cases of gas gangrene—due, probably, to diminution of the alkali reserve.

As regards their immediate treatment, cases may be divided into four classes:—

1. Almost all simple fractures, and compound fractures with clean wounds of entry and exit, can usually be put up without an anæsthetic. In the few cases where accurate alinement cannot be obtained, a general anæsthetic may be administered, and the muscular relaxation thus afforded greatly assists the accurate correction of the deformity.

2. In other cases, where the patient's general condition is critical, and there is no immediate indication for further operation on account of spreading sepsis or gas infection, the permanent splinting should be delayed until the general condition has been improved by twenty-four to forty-eight hours' undisturbed rest in bed, together with the usual restorative measures.

3. In cases in which the knee-joint has been directly involved in the original wound, advantage is gained by maintaining absolute rest for the limb, the manipulations necessary to correct the associated fracture deformity involving risks of lighting up infection in the joint. These cases have usually been cleaned up and immobilized on a Thomas splint at the casualty clearing station, and the correction of the fracture should be delayed until the fate of the joint is evident.

In classes 2 and 3, the correction of the deformity can be made in successive stages, with a minimum disturbance of the parts, by: (*a*) Application of foot-piece and glue extension; (*b*) Gradual flexion of splint at the knee to the required degree by the use of a pair of wrenches; (*c*) Necessary adjustments of flannel slings.

4. In many cases, however, it is necessary to give the patient a general anæsthetic in order that his wounds may be more thoroughly examined and cleaned up, and his fractured limb placed on the splint on which most of his subsequent treatment is carried out. For many reasons this is done in the operating theatre, not in the ward, even in cases in which simple cleaning and splinting appear to be all that is required. The developed skiagrams are placed in a viewing box in the theatre, and are thus available for ready reference while the fracture is being dealt with.

PROCEDURE IN THE OPERATING THEATRE.

General.—The anæsthesia usually employed is chloroform induction, followed by Shipway's apparatus for the administration of warmed ether and chloroform vapour. In addition to the heating arrangements of the theatre, several hot-water bottles are

distributed about the patient, and he is well packed with blankets. Unnecessary exposure is carefully avoided.

Cleansing of the Limb, etc.—When the patient is well under the anæsthetic, his temporary splint is gently removed and the limb cleaned. It is generally necessary to remove the extension applied at the casualty clearing station. With the wounds protected with sterile gauze, the whole limb is scrubbed with warm water and soap. In cases where a Thomas splint is to be applied to the sound limb, this is dealt with in the same manner as the fractured limb. The limb is shaved, and then cleaned by several applications of spirit.

Some authorities state that it is not necessary to shave the limb, but for the following reasons we always do so: (*a*) It is the best method of thoroughly cleansing and preparing the skin, and adds greatly to the after-comfort of the patient; in many cases the skin is so dirty that it is not possible to cleanse it thoroughly without shaving; (*b*) The development of vermin beneath the extension strip is prevented; (*c*) Less blistering and skin irritation under the extension strip result.

The skin in the neighbourhood of the wound area is painted with 3 per cent picric acid and spirit, and sterile towels are disposed round the wounds. The surgeon and assistant wash up and put on sterile rubber gloves preparatory to dealing with the wound itself.

Surgical Treatment of the Wounds and Fracture.—In most cases, by the time a patient has reached a base hospital little benefit is likely to result from excision of wounds where this has not been thoroughly performed at the casualty clearing station—with the exception of the wound in the bone, which will be discussed later. In almost all cases the wounds and fracture have been dealt with by a casualty clearing station surgeon; but, as already stated, the methods used vary greatly—especially in the thoroughness of excision of the wounds, in the application of particular antiseptics, and in the degree to which primary suture has been then carried out. Where primary suture has been performed after wound excision and the application of some one or other paste or solution, better results would be obtained if it were possible for the surgeon who has operated to keep the case under his own observation for the first few days. The necessity for early evacuation of these cases during periods of rush, and the journey to the base, have much to do with the infected condition of many wounds on arrival. In war surgery, patients pass through the hands of several surgeons; and it should be a principle of treatment that further operations should only be performed in the presence of definite indications. These are, at this stage: (1) *Spreading sepsis or gas infection in incompletely drained wounds*; (2) *Insufficient removal of bone fragments*; (3) *Vascular gangrene of the limb.*

1. Spreading Sepsis or Gas Infection in Incompletely drained Wounds.—In many cases the wound has been firmly packed with gauze which has acted as a plug, blocking wound discharges, and favouring the spread of sepsis in the depths of the wound. This gauze and any sutures present are removed. In some cases this may furnish sufficient drainage, but in many further incisions are necessary. Wherever possible, these are made by extending the wounds or incisions already present. If, however, they are badly situated for drainage, fresh incisions are required, and are usually made on the outer aspect of the limb, along the line of the external intramuscular septum, the fascia lata being incised at right angles. Incisions may be necessary in other regions of the thigh, but in the following situations they are avoided if it is at all possible: (*a*) *Adductor region*, on account of the danger of opening up the tissue planes in the region of the main vessels, and of the difficulty of obtaining free drainage, owing to the depth of the bone from the surface and the unfavourable anatomical arrangement of the muscles; (*b*) *Posterior region*, on account of the position of the sciatic nerve, and the obstruction to drainage caused by the slings supporting the limb in the splint; (*c*) *Popliteal region*, on account of the presence of the popliteal vessels and nerves, and of the difficulty of dealing with sepsis in this area; (*d*) *Buttock*, owing to the tendency for sepsis to spread widely in the gluteal region, and the interference with the subsequent application of the ring of a Thomas splint. Incisions for drainage should be

made to the full extent necessary to expose the whole of the infected area. When they are made—as is almost always the case—on the lateral aspect of the thigh, little subsequent disability need be feared, as the incision is parallel to the length of the limb and the direction of the muscle fibres, and leaves an almost linear scar on healing.

It is rarely necessary to insert tubes for drainage. In cases where the track of the wound passes along an indirect route, drainage is assisted by inserting a folded piece of ordinary rubber-glove tissue.

After securing absolute hæmostasis, the wounds are cleaned with alternate applications of hydrogen peroxide and hot normal saline. Gauze dressings are applied, either dry, or moist out of hot saline. Formerly Carrel tubes and instillation of eusol or Dakin's solution were used in all cases, but latterly only in very septic cases where it was not possible to thoroughly expose all the recesses of the wound. In cases in which thorough drainage has been provided, frequent cleansing of wounds and application of ordinary gauze dressings has given better results. These are also more convenient to work with, and the necessary manipulations of the limb and fracture during the after-treatment are rendered easier.

Gas Infection.—This complication has been frequently met with, and is usually evident on admission or within a few hours. Ninety per cent of the deaths occurring within the first few days have been due to this cause. It is rarely possible to excise the infected tissue, on account of the extent of the infection present; and even in cases where this is localized to a muscle or group of muscles, the dissection required is so extensive that it is rarely practicable, as is sometimes the case in other regions of the body. In the cases fit for operation, rapid amputation is usually performed. Sodium bicarbonate (3 per cent) and glucose (1 per cent) are given intravenously, and later, in the wards, by mouth and rectum.

2. Insufficient Removal of Bone Fragments.—Considerable difference of opinion exists on the question of the degree to which bone fragments should be removed. The practice of French surgeons is to excise them to a much wider degree than is usual with British surgeons. At the casualty clearing station the wounds in the skin and soft parts have generally been excised, and latterly much more thoroughly than previously; but almost always in the case of bone fragments the same systematic attempt to excise devitalized and infected tissues has not been carried out, and further operation for their removal is necessary at the base.

Bone fragments which have been driven into the soft parts for some distance from the site of fracture are removed, as, even if they survive, they will be of no use in the subsequent repair of the bone, and, what is of more importance, they are potent causes of sepsis. In our earlier cases it was the practice to leave any fragment in the region of the fracture which possessed sufficient periosteal attachment to ensure a reasonable chance of its ultimate survival. While a number of these cases healed and obtained good union, yet in a large proportion osteitis at the site of fracture, with formation of sequestra and persistent sinuses, necessitated further operation at a later date. In our later cases we have excised bone fragments more freely, with much advantage, as shown by the more rapid healing of wounds, better callus formation, and less resulting sclerosis of muscles and soft parts, giving a better functional result. The removal of infected bone fragments—and important amongst these are fragments driven into the medullary cavity of the bone—also provides more thorough drainage of the site of fracture. As Colonel Burghard states in his preface to the English translation of *Traitement des Fractures* by Professor R. Leriche: "Put concisely, the position is, that one school regards as its bugbear possible want of union as the result of removal of fragments from an infected fracture, while the other attaches prime importance to the persistent suppuration and loss of function to which the retention of septic fragments is so likely to lead." Non-union in cases of compound fracture of the femur in men of military age is extremely rare, not more than 1 per cent. The capacity of the femur for forming callus is markedly greater than such bones as the tibia and humerus, and even where the separation between the fractured ends of the femur has been as much as three inches, firm union has resulted.

3. Vascular Gangrene of the Limb.—A few cases have been met with in which the limb on admission has shown the signs of ordinary vascular gangrene. The femoral vessels may have been found injured and have been ligated at the casualty clearing station. In other cases there is arrest of circulation in the limb with no direct indications that the injury to the main vessel has been previously evident. These are usually due to partial or even complete tearing of the vessels, followed by occlusion, either by pressure from blood extravasated into the tissues or from thrombosis.

If, at operation, it is found that the femoral vessels are exposed in the wound, the condition of these should be carefully ascertained. In the presence of sepsis, partial lesions of the arterial wall, involving the outer coat only, result almost always in secondary hæmorrhage. Ligature of such an injured artery above and below, in an already infected wound, is so often followed by vascular gangrene that in these cases our practice now is to amputate while the condition of the patient is good, instead of being compelled to do so at a later date when it may fail to save his life. With a comparatively clean wound, the probability of survival of the limb after occlusion of the main vessels is much greater, and the prognosis is better if the artery is involved in Scarpa's triangle or in Hunter's canal than if in the popliteal space. Several cases have been met with in which the femoral vessels were lying exposed in septic wounds but with no evidence of injury to the vessel walls. Secondary hæmorrhage has resulted in a proportion of these; but in a greater number the wounds and fracture have done well.

Two of our cases of simple fracture in the lower third were associated with injury to the main vessel, and in one the knee-joint was distended with blood. In both there was marked extravasation at the site of fracture. The pulse was absent in the tibial arteries in both cases, and did not return during the after-treatment. In both, normal union of the fracture occurred and good functional limbs resulted.

Extreme Degree of Trench Foot.—A few cases of trench foot have been met with. All of these except one were of minor severity, merely delaying the application of the foot-piece for a few days. In one case gangrene was present, necessitating amputation; the patient's general condition was critical, and as there was considerable sepsis at the site of fracture amputation was performed at this level.

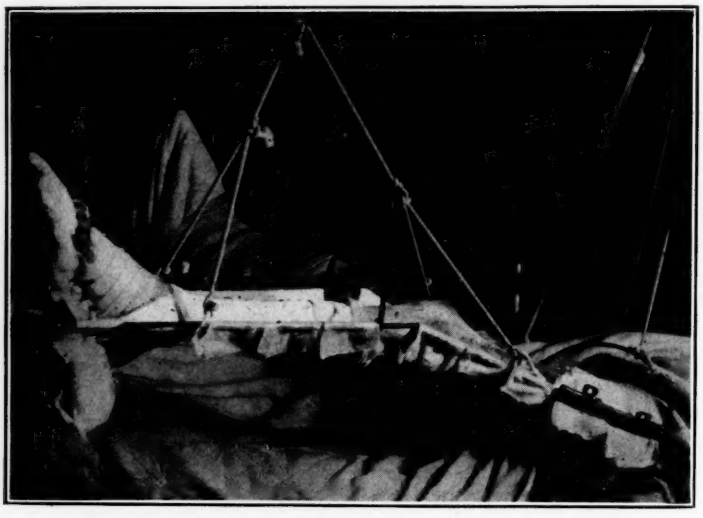


Fig. 304.—Hodgen splint. Compound fracture of upper third of femur, with large buttock wound.

Selection of Splint.—The type of splint used in any particular case is determined by: (1) The position and extent of the wounds in soft parts; (2) The site of fracture.

Thomas knee-splints have been used in all cases except those with extensive wounds of the buttocks and posterior aspect of the thighs; and in these a Hodgen splint (*Fig.* 304)

has been applied on the fractured side until the healing of the wound has sufficiently far advanced to permit the application of a Thomas. It is possible to obtain better control of the fracture with the latter splint. In some cases the wounds of the buttocks and pelvis are so extensive that no splinting is possible, and in these a Sinclair net bed (*Fig.* 305) permits of the comfortable nursing of the patient as well as accurate control of the fragments. Bryan's bed was used in some of our earlier cases.

A Thomas splint is selected which fits the patient so that the hand can readily be passed between the limb and the thigh in front. This is usually Size 21 or 23. The

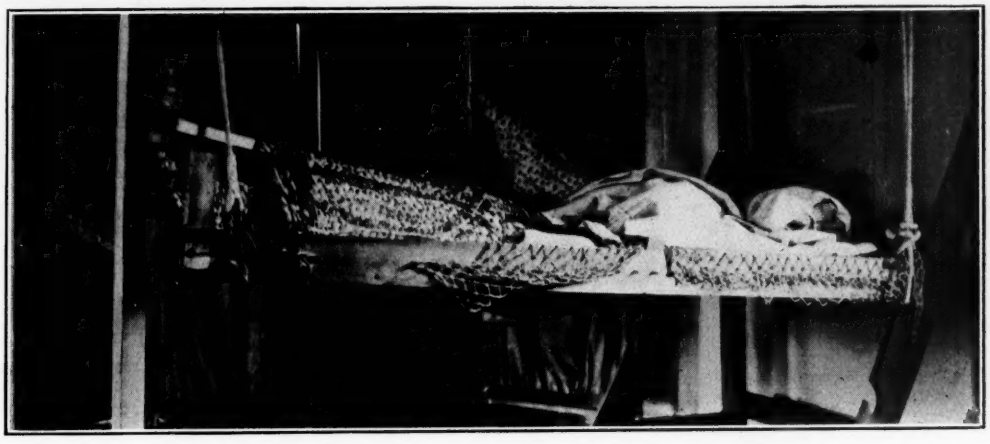


FIG. 305.—Sinclair net bed. This patient was under treatment for multiple wounds with pressure sores, and not for fractured femur.

smaller the ring the easier it is to maintain the splint accurately in apposition with the tuber ischii, and to perform necessary manipulations and adjustments of the fracture. Large rings are less comfortable for the patient, and increase the difficulties of nursing. Before application the leather of the ring of the splint is softened by rubbing it with soft soap or vaseline.

A Thomas knee-splint is applied to each limb in fractures of the head, neck, or upper third of the femur. In fractures below this level a single Thomas is used.

Methods of Extension.—Extension is usually obtained by means of Sinclair's glue, to which is applied a long strip of folded gauze on each side of the limb. Care should be taken that the glue is not too hot; it should be tested on the forearm before application. The gauze strips should be firmly and evenly applied, and then bandaged without creasing. Irritation and blistering of the skin occurred under the extension strips in a certain proportion of cases (about 10 per cent), and other preparations have been tried, such as ordinary adhesive plaster and mastisol; but these have shown no advantage over glue. In any method of extension which depends on the adhesion of the extending material to the skin, the pull required has to be maintained over many weeks, and the skin is subjected to a considerable strain. It is this direct mechanical effect which is largely responsible for the irritation and blistering, and consequently care should be taken that the extending force is evenly distributed on both sides of the limb.

In some cases any method of efficient extension from the skin is impossible owing to associated wounds below the site of the fracture of the femur, such as compound fractures or extensive wounds of the soft parts of the leg. For these we have obtained efficient extension by means of a pair of calipers (engineer's) inserted into the condyles of the femur (*Figs.* 306, 307). The type of calipers used and the technique of their introduction are as devised by Major M. Sinclair, who supplied us with our first pair.

The ends of the calipers are straightened, and then bent in at right angles, and the points tapered to be of the same size as that of a medium bone-drill. Over each limb of

the caliper is fitted a tubular metal guard, which allows the point of the caliper to protrude ¼ in. only. On the outer end of this guard is a small flat metal strip, through a hole

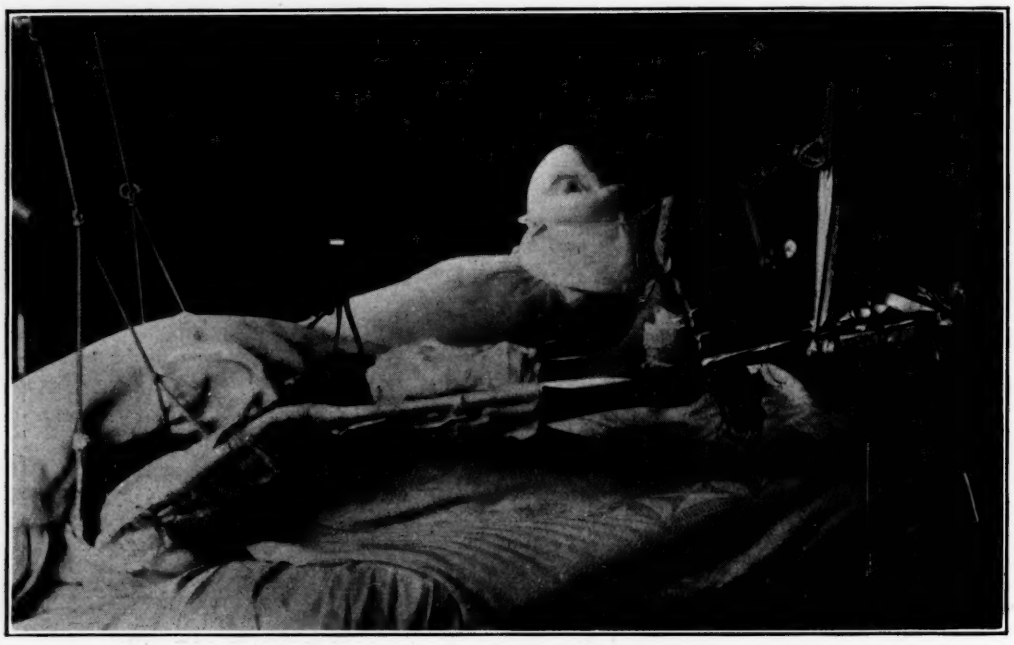


FIG. 306.—Extension by means of calipers inserted into lower end of femur. Compound fracture of upper third of femur, with division of sciatic nerve, and compound fracture of tibia and fibula. (See *Figs.* 307, 310.)

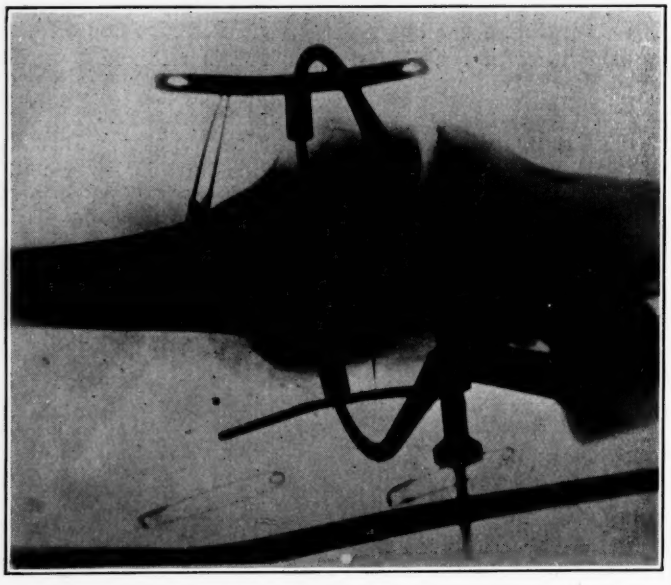


FIG. 307.—Radiogram of calipers inserted into lower end of femur for extension.

in the end of which the extension is taken by means of strong tape. To insert the calipers a general anæsthetic is given and a small incision made down to the bone over the most prominent point of each condyle—this is about one inch from the margin of

the patella on each side, and one inch above the level of the joint. The guards are introduced into the wound, and through the tube the bone is drilled to a depth of $\frac{1}{4}$ in., and the point of the caliper inserted. The advantage of this method is that the cancellous tissue is not tunnelled, as in Hey Groves' and Steinmann's methods, and perfect extension can be obtained.

Some surgeons advocate the routine use of some form of caliper or transfixion method in preference to extension applied to the skin, and claim that subsequent disability of the knee-joint is avoided, as the knee can be freely moved during the after-treatment without interfering with the extension. We prefer the ordinary method of skin extension wherever this is possible, as movements at the knee can still be carried out, as will be described later; and one avoids the undoubted additional risk of sepsis occurring at the site of operation in patients whose wounds are often already infected.

Foot-pieces.—In all cases a Sinclair wooden foot-piece (*Fig.* 308) is applied to the fractured limb, and a combined foot-piece and bed-rest to the sound limb whenever two Thomas splints are used. To apply the former, five or six strips of flannel, $\frac{3}{4}$ in. wide,

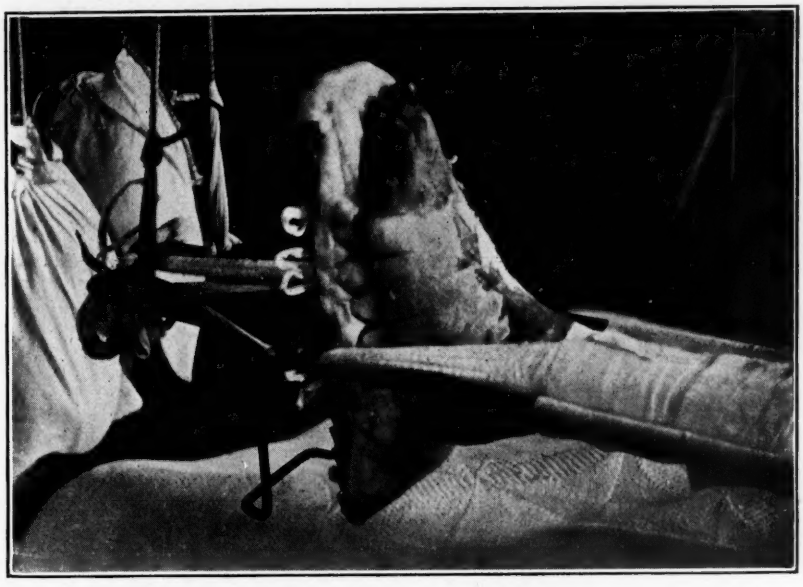


FIG. 308.—Sinclair foot-piece.

with two small curtain rings threaded over each, are glued to the sole and sides of the foot. The rings are arranged to lie along the inner and outer borders of the foot. Cotton-wool is then dabbed over the glued area. The foot-piece is padded with cotton-wool, disposed so as to maintain the normal arch of the foot, and covered with a strip of flannel, the ends of which are fixed to the back by drawing-pins. To each ring is attached a length of tape, the ends of which are passed over the notches on the sides of the foot-piece, and tied together at the back. The foot-piece rides on the side-bars of the Thomas splint by means of an adjustable metal bar, which can be moved up and down in a vertical slot in the foot-piece and clamped in any desired position. Thus, the foot can be raised or lowered, inverted or everted, flexed or extended, and maintained in any desired position by tapes attaching the ends of the cross-bar to the end of the splint. To the sole of the foot of the sound limb a strip of gauze is glued, and attached to the loop at the top of the combined foot-piece and bed-rest.

Materials used for Slinging the Limb in a Thomas Splint.—

1. *Flannel Bandage.*—Each sling is looped around the inner bar of the splint, and fixed on the outer side by means of a large safety-pin or paper clip.

2. *Unbleached Calico*—Has the advantage over flannel that it does not stretch so much, and therefore slings of this material do not require so frequent adjustment. It has not been used as much as flannel, owing to the difficulty in obtaining it.

3. *Jaconet*—Is used by some in the region of the fracture if there is much discharge. We prefer, however, to use sterile flannel or calico slings changed daily. These form part of the dressing itself, the greater part of which is applied outside the sling and kept in place by a triangular bandage. The objections to jaconet are that it is not cleanly, it readily stretches, safety-pins are difficult to insert, and they rust quickly.

4. *Perforated Zinc.*—Strips of perforated zinc covered with flannel are excellent for transport and for simple fractures after the deformity has been corrected.

Application of the Splint.—

1. *Fractures of the Lower Third.*—The deformity in these cases is very constant. The ower fragment is displaced markedly backwards, and slightly inwards, due to the action of the gastrocnemius, popliteus, and adductor magnus. In some the fracture is transverse and situated immediately above the condyle; but in a greater number it is oblique and at a slightly higher level. The main vessels are extremely liable to injury by the sharp spiky end of the lower fragment. Where the obliquity is from behind forwards and upwards, and there is not much shattering, the upper end of the lower fragment may be displaced behind the lower end of the upper fragment, and offer considerable mechanical obstruction to reduction (*Fig.* 309).

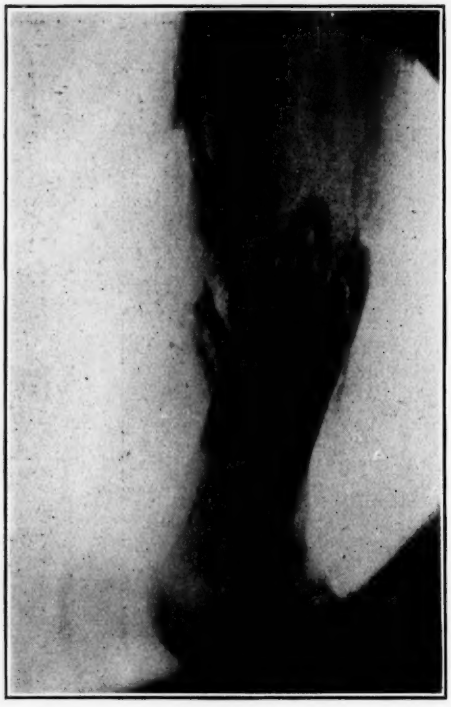


FIG. 309.—Comminuted fracture of lower third of femur, with persistent backward displacement of lower fragment; reduction obstructed by sharp lower end of upper fragment.

With the manipulations and extension necessary to correct the deformity, flexion of the hip- and knee-joint is necessary; and in order to counteract the tendency to recurrence of the displacement, the muscles acting on the fragments are relaxed by flexing the splint at the level of the knee-joint 15 to 20 degrees.

It is sometimes stated that by the flexion of the splint in this way the essential principle of the Thomas knee-splint is departed from, and that the Thomas splint then acts in the same way as a Hodgen. The essential principle of the Thomas knee-splint is the fixed extension from the tuber ischii. The more the splint is flexed, the greater is the difficulty of maintaining this fixed extension; but, with the small degree of flexion actually employed, this can still be efficiently carried out, although the extending force is less in the direct line of the limb.

The small size of the lower fragment renders difficult its direct manipulation into accurate position. The following manœuvre, originally shown us by Major Sinclair, is most effective in bringing forward the backwardly displaced upper end of the lower fragment. The ring of the Thomas is slipped over the limb and pushed home against the tuber ischii. A doubly-looped flannel sling is passed beneath the upper end of the lower fragment, and fixed to the splint. The whole lower limb below the site of fracture is levered over this sling, using it as a fulcrum, the leg being extended as much as possible; flexion occurs at the site of fracture, and the backwardly-displaced lower fragment comes forward into position.

The gauze extension-strips are securely tied to the end of the splint while traction

is being maintained, the remaining slings required to support the limb are then placed in position, and the foot-piece is applied as already described.

2. *Fractures of the Middle Third.*—The displacement in these fractures varies. Those towards the upper or lower third show to a lesser degree the respective deformities associated with fractures in these situations. Here also may occur long oblique and spiral fractures associated with axial rotation of fragments, or fractures with total loss of the shaft for some inches. Grooved or incomplete fractures, or clean perforations of the bone, are very much rarer than in the upper or lower third, especially the latter, owing to the different construction of the bone.

For these cases a single Thomas splint flexed opposite the knee is applied, except in those in which the displacement of the upper fragment is similar to that of a fracture in the upper third, when a Thomas splint is also applied to the sound limb. In correcting the displacement, particular care should be taken to restore the normal antero-posterior curve of the shaft of the femur.

3. *Fractures of the Upper Third.*—This class includes those in which the fracture is situated between the neck and a point 4 to 5 in. below the lesser trochanter; and the displacement of fragments varies with the relation of the fracture to the muscular attachments to the trochanters and upper portion of the shaft—in particular, the insertion of the ilio-psoas into the lesser trochanter, and of the glutei and external rotators in the region of the greater trochanter. The commonest type is that below the lesser trochanter, in which the upper fragment is flexed, abducted, and externally rotated. In some the lesser trochanter is completely detached from both fragments; in others the fracture is oblique between the trochanters, so that the ilio-psoas acts on the lower fragment. Even in fractures situated high up in the region of the great trochanters, simple fissuring into the hip-joint rarely occurs, although associated injury to the joint and pelvis (*Fig.* 310) is frequently met with. This, of course, is due to the architectural arrangement of the bony cancelli in the region of the neck of the femur.

FIG. 310.—Comminuted fracture of upper third of femur, with sharp upper end of lower fragment driven into hip-joint. Extension obtained by calipers from lower end of femur. See *Figs.* 306, 307.

In these fractures a Thomas knee-splint is applied to the sound as well as to the fractured limb, in order that the pelvis may be immobilized as far as possible. Both splints are flexed opposite the knee. The accurate correction of the deformity—more especially the abduction—is carried out afterwards in the ward, as will be described later.

In our experience a pair of Thomas knee-splints fixed in abduction has the following advantages over an abduction frame: (*a*) It permits of readier access to the wounds; (*b*) Nursing is easier; (*c*) Varying degrees of abduction, flexion, and rotation can be accurately obtained; (*d*) Skiagrams during the treatment can be taken with the splints in position; (*e*) Patients are more comfortable.

4. *Fractures of the Head and Neck.*—These are often associated with fractures of the pelvis, particularly of the acetabulum or of the pubic or ischial rami. There may also be lesions of the pelvic viscera. As in fractures of the upper third, two Thomas splints are employed, but without flexion at the knee-joint; and the accurate correction of the deformity is carried out in the ward.

WARD AFTER-TREATMENT.

Description of Special Wards.—The after-treatment of cases of compound fracture of the femur is difficult in the absence of special conveniences and appliances. In each of the femur wards was erected a wooden superstructure running the whole length of the ward on each side. The details are shown in *Figs.* 311–315.

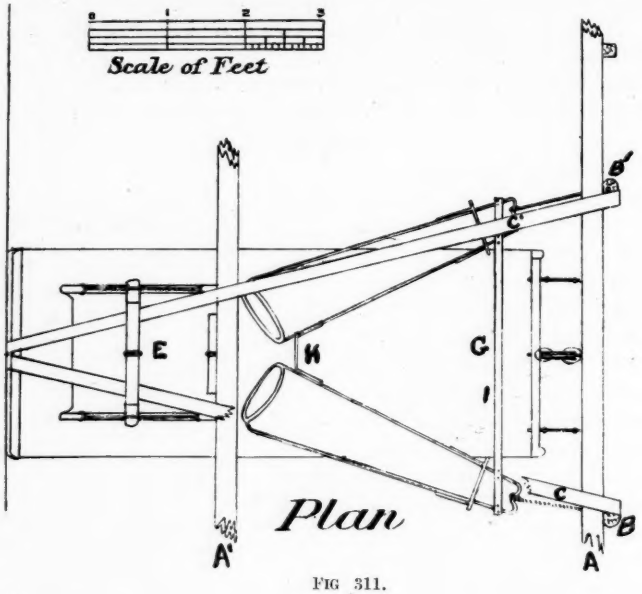


FIG 311.

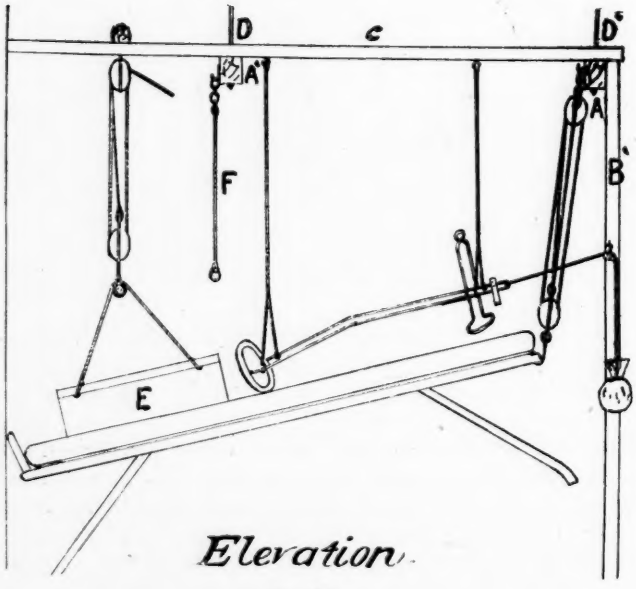


FIG. 312.

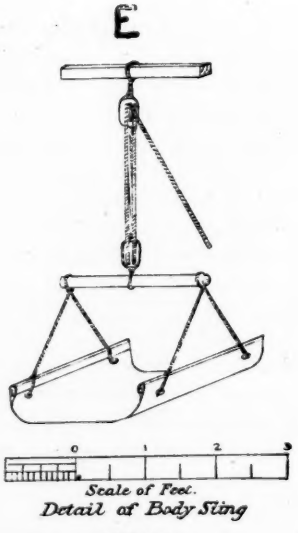
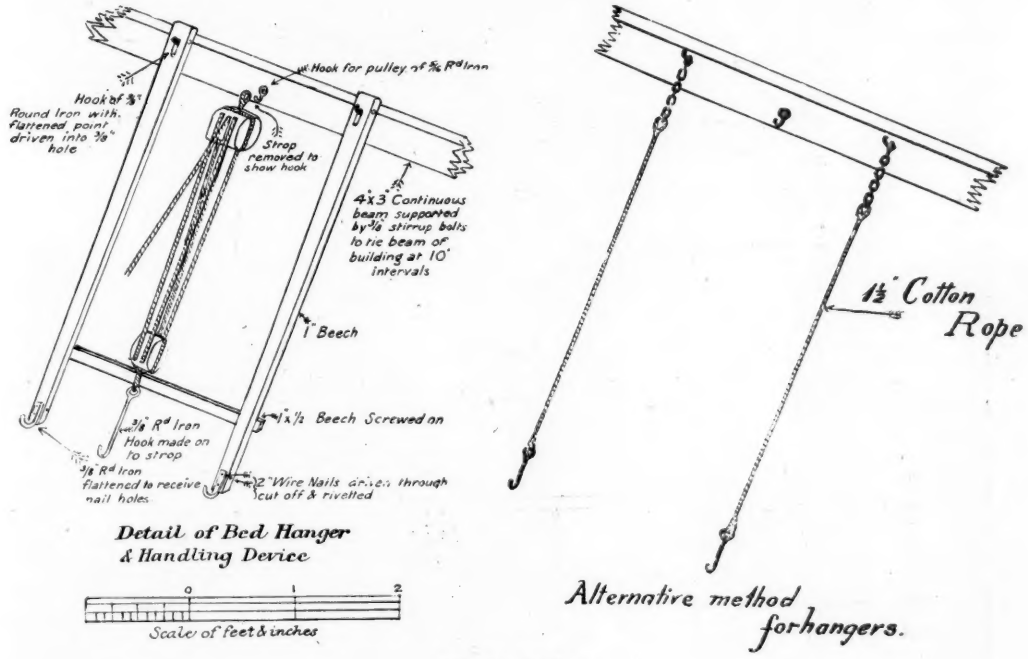


FIG. 313.

Two parallel main beams (4 in. by 3 in.) A and A^1, running lengthwise along the ward are suspended from the tie-beams of the ward 7 ft. above the floor by stout iron rods D and D^1, placed at 10-ft. intervals. A is 7 ft. 6 in. out from the wall of the ward, i.e., 1 ft. beyond the foot of the bed. A^1 is 3 ft. from the wall, i.e. from the head of the bed.

Opposite the foot of each bed are two vertical uprights B and B[1], secured by screws to the floor below and to the main beam A above. These uprights can be fixed in any desired position of separation or approximation. Resting on the main beams A and A[1], are two movable wooden abduction bars C and C[1]. Over the head of the bed these come together and rest on a small wooden block fixed to the wall of the ward opposite the central line of the bed. The abduction bars are attached to A and A[1] by screws, and at the foot of the bed correspond in position to the uprights B and B[1]. These abduction bars are used for the following purposes: (*a*) For the attachments of the necessary hooks and pulleys for suspending the splints; (*b*) For attaching the canvas sling E (*Figs.* 312, 313); (*c*) By altering their angle any required degree of abduction may be obtained. From A[1] opposite the middle line of each bed is suspended a rope and bar F for the


Hook for pulley of ⅝ Rd Iron
Hook of ⅝" Round Iron with flattened point driven into ⅞" hole
Strop removed to show hook
4"x3" Continuous beam supported by ⅞ stirrup bolts to tie beam of building at 10' intervals
1" Beech
⅜ Rd Iron Hook made on to strop
1"x½ Beech Screwed on
⅜ Rd Iron flattened to receive nail holes
2" Wire Nails driven through cut off & rivetted
Detail of Bed Hanger & Handling Device
0 1 2
Scale of feet & inches
1½" Cotton Rope
Alternative method for hangers.

FIGS. 314, 315.

patient to raise himself. Attached to the beam opposite the foot of each bed is a device for keeping the foot of the bed raised (*Figs.* 314, 315). The legs at the head of each bed fit into small blocks which prevent the bed from slipping when the foot is raised. An advantage of the whole arrangement is that the two vertical uprights are the only portions of the structure which rest on the floor, and the floor space between and around the beds is quite free.

Method of Suspension when a Single Thomas Splint has been applied (*Fig.* 316).—White cotton cord ⅓ in. in thickness is used as the suspending material. A loop about 2½ ft. long is attached at each end of the splint. To the centre of this is tied a long piece of cord, the end of which carries a weight. Each cord runs over two pulleys—the first pulley in each case is attached to the abduction bar slightly nearer the head of the patient than the attachment of the corresponding loop to the splint. The second pulleys are attached to the main beam A (*Fig.* 311), just inside the vertical upright, so that the weights are less likely to be disturbed on passing between the beds. The weights used are such that the limb in the splint remains in any position in which it is placed. The weight acting on the upper end of the splint is made a pound or two heavier than that acting on the lower end, so as to assist the patient to raise his pelvis in bed. The weight

and pulley suspension, by allowing a patient to change his position in bed at will, greatly facilitates the nursing, and a certain degree of movement of the hip-joint is permitted.

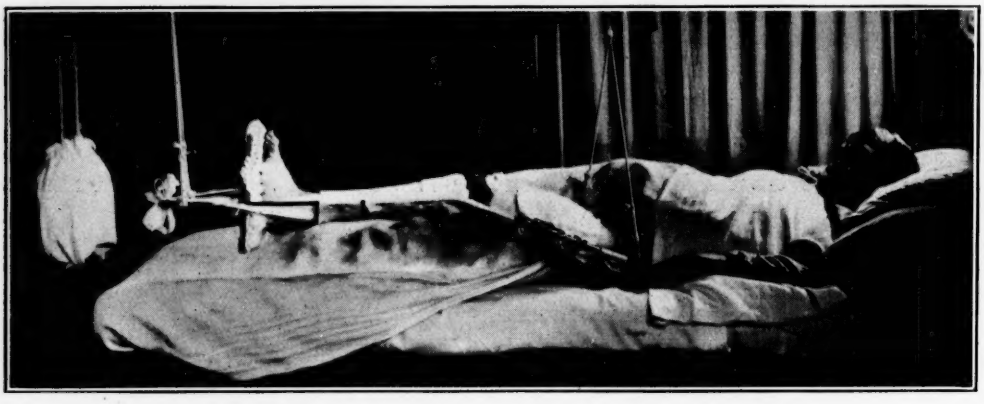


FIG. 316.—Single Thomas knee-splint suspended by weights and pulleys.

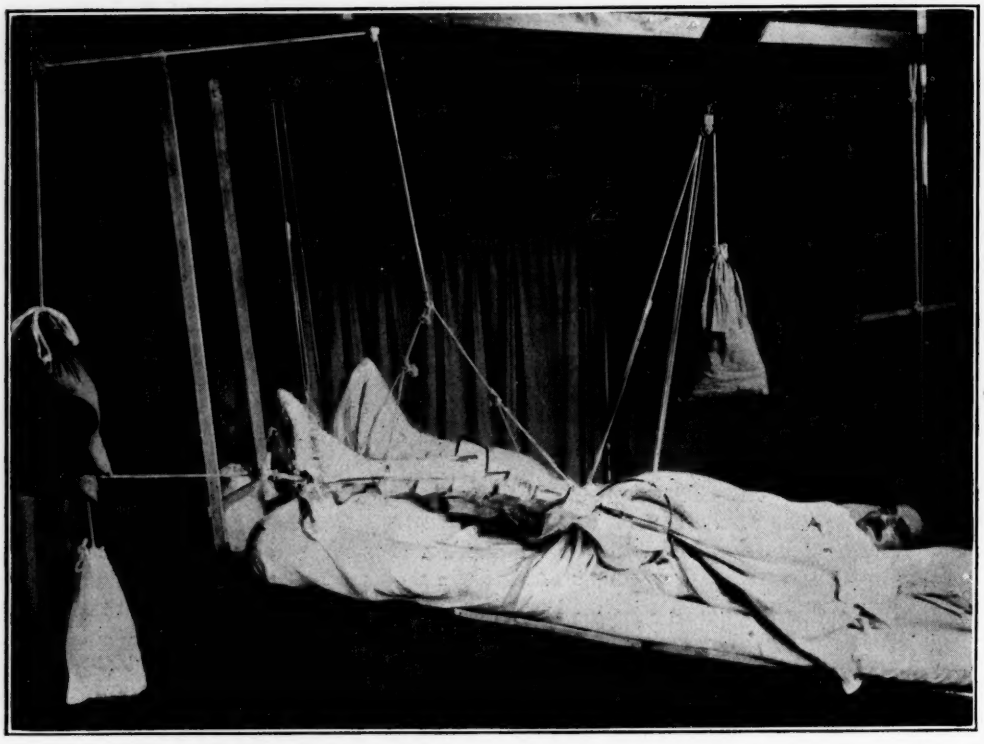


FIG. 317.—Compound fracture of upper third of femur, with large buttock wounds. Hodgen splint to fractured side. Thomas splint on sound limb. See *Figs.* 326, 327.

Method of Suspension when Two Thomas Splints have been applied (*Fig.* 318).—On the patient's return from the theatre :—

1. The foot of the bed is raised. By so doing the counter-extension action of the body-weight is made use of, and the bed is only lowered when it is desired to obtain access to the wound or for the ordinary nursing attentions.

2. To the upper and lower ends of each splint a loop of cord is attached as previously described. The cord from the centre of each loop is tied to a hook in the abduction bar, again slightly nearer the head end than its attachment to the splint. The length of the cord is such that the limbs are just free of the bed, and their tension is so regulated that no sagging occurs when the bed is lowered. At first, suspension by weights and pulleys was used instead of this fixed suspension, but it was found that the same immobilization of the pelvis and splints was not obtained when the bed was lowered.

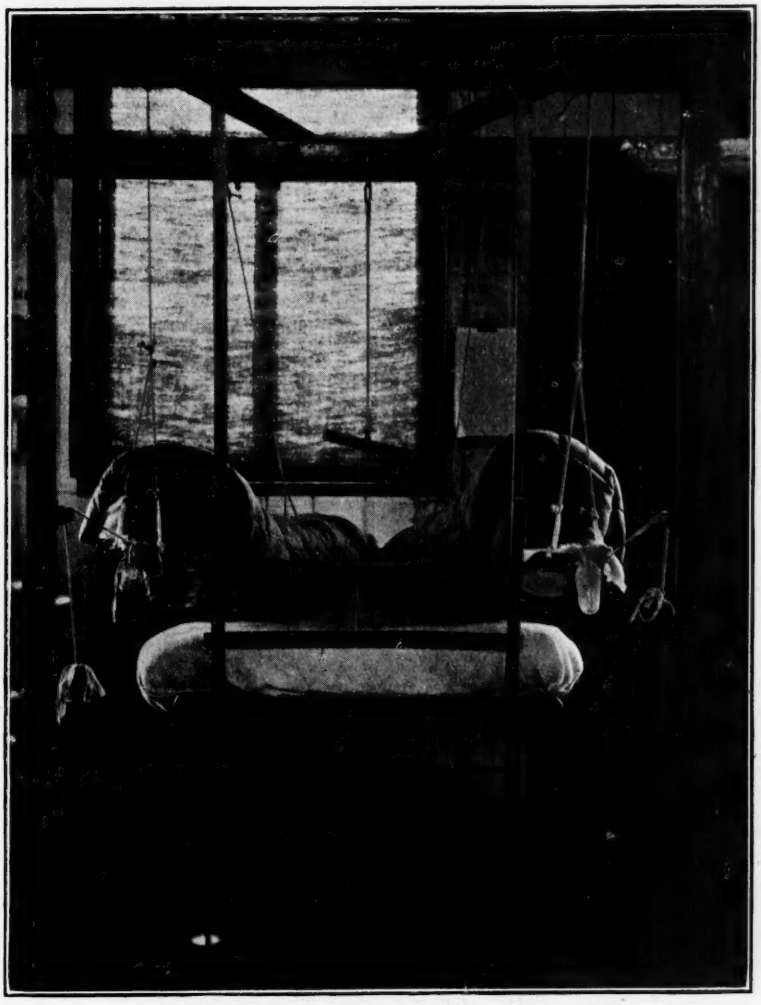


FIG. 318.—Suspension when two Thomas splints have been applied.

3. The lower ends of the splints are connected by a wooden 'spreader' G (*Fig.* 311). These spreaders are made of lengths from 3 ft. 6 in. upwards, according to the degree of abduction required. The upper ends of the splints are connected by means of an ordinary spring wire foot-piece, which is bound to each inner bar by adhesive strapping. The pelvis is thus efficiently immobilized, and forms the apex of a fixed triangle.

4. To the end of each splint is attached a weight by a cord passing over a pulley fixed to the upright, at such a height that the pull exerted is in the direct line of the splint.

FIG. 319.

FIGS. 319, 320, and 321.—Showing application of sling and lowering of bed to obtain access to wounds or to carry out the ordinary nursing attentions.

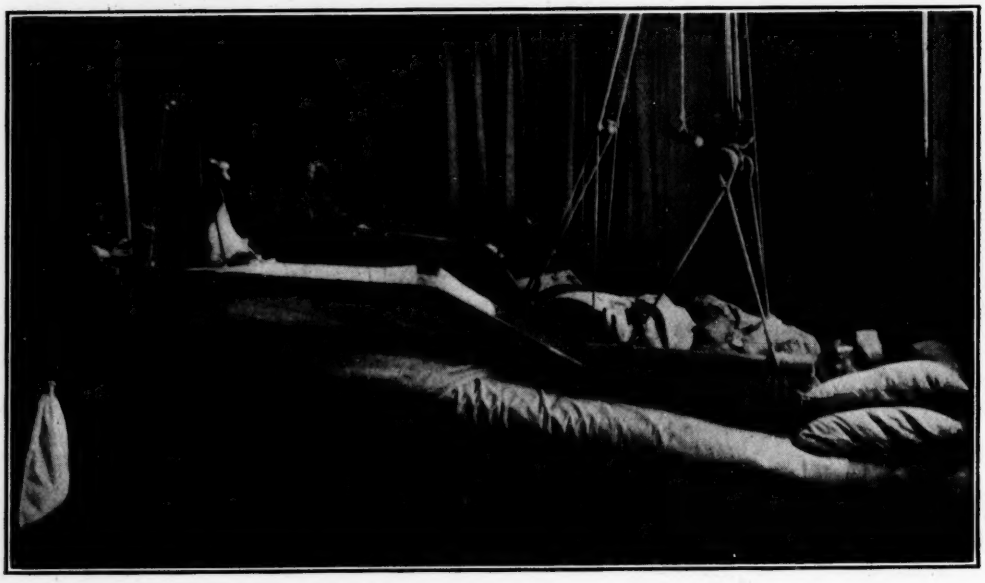


FIG. 320.

The weight is so adjusted as to counteract the tendency of the patient to slide towards the head of the bed, especially when the foot of the bed is raised. At first, the ends of the splints were simply tied to the uprights in order to effect this, and also to furnish the fixed point against the counter-extending body-weight. The weight and pulley were later substituted, as they were found more satisfactory for the following reasons: (*a*) The tension of the cord is constant, and does not need frequent readjustment owing to voluntary movements of the patient in bed; (*b*) Owing to the slight give-and-take permitted by the weight and pulley, the Thomas splints are kept in better apposition with the tuber ischii, and the glue extension requires less frequent renewal; (*c*) Where additional extension is desired, extra weight may be used to supplement the fixed extension obtained from the tuber ischii.

Method of Employment in the Nursing of the Patient (*Figs.* 319–321).—When it is necessary to obtain access to the wounds or to carry out the ordinary nursing attention, the canvas sling E (*Fig.* 312) is slipped under the patient's back and adjusted evenly. As will be seen in *Figs.* 320, 321, the sling extends from above the shoulders to below the iliac crests, and particular care should be taken that it takes a firm grip of the

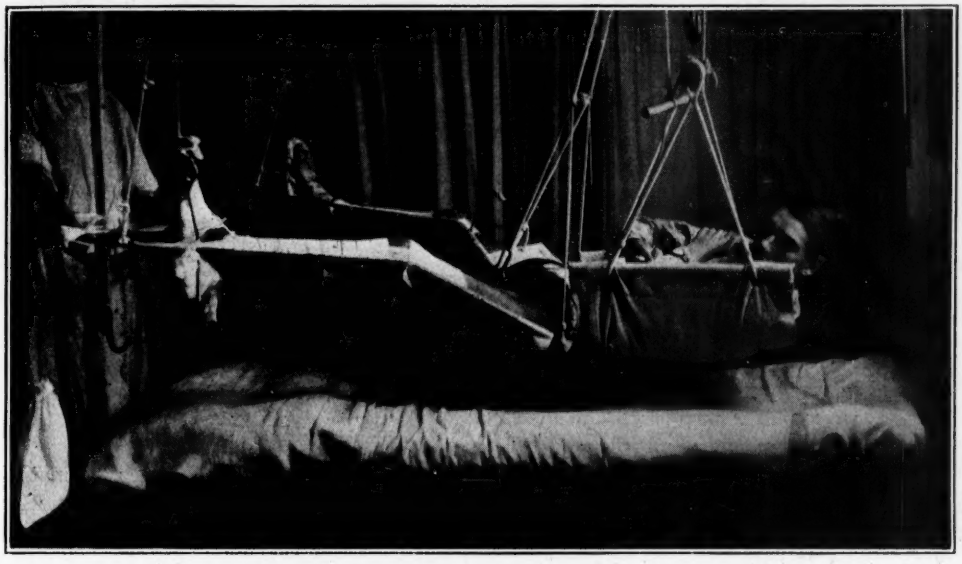


FIG. 321.

pelvis. The sling is attached by two chains on each side to hooks on the abduction bars, or by a block-and-tackle arrangement, shown in *Fig.* 313, so as just to take the weight of the patient. The foot of the bed is then disengaged and lowered. The patient is thus suspended by the sling and the cords attached to the splints. If the sling has been well applied, the relative position of the body and pelvis to the lower limbs is unaltered. No discomfort or pain is caused, and the position may be maintained for any desired length of time. If need be, the whole bed can be removed and be replaced by a fresh one.

Alternative Device for Cases where Two Thomas Splints have been Applied (*Fig.* 322).—In one of the wards cases of fracture of the upper third were treated with the following arrangement, devised by the late Major W. S. Garnett, A.A.M.C. The flexed Thomas splints are applied, and their lower and upper ends connected as already described. The foot of the bed is not raised, and extension is maintained solely by means of the ordinary gauze strips tied to the ends of the splints. The lower ends of the splints are suspended by cords from the abduction bars, while to the ring of each splint is attached a cord

carrying a weight, passing over a pulley. The cord is attached to the anterior part of the ring of the splint diagonally, opposite the ischial tuberosity, and the direction of the pull of the weight is thus upwards and slightly outwards. The weights are so adjusted that when the patient pulls himself up in the canvas sling by means of a block and tackle, the rings of the splints follow the upward movement of the pelvis.

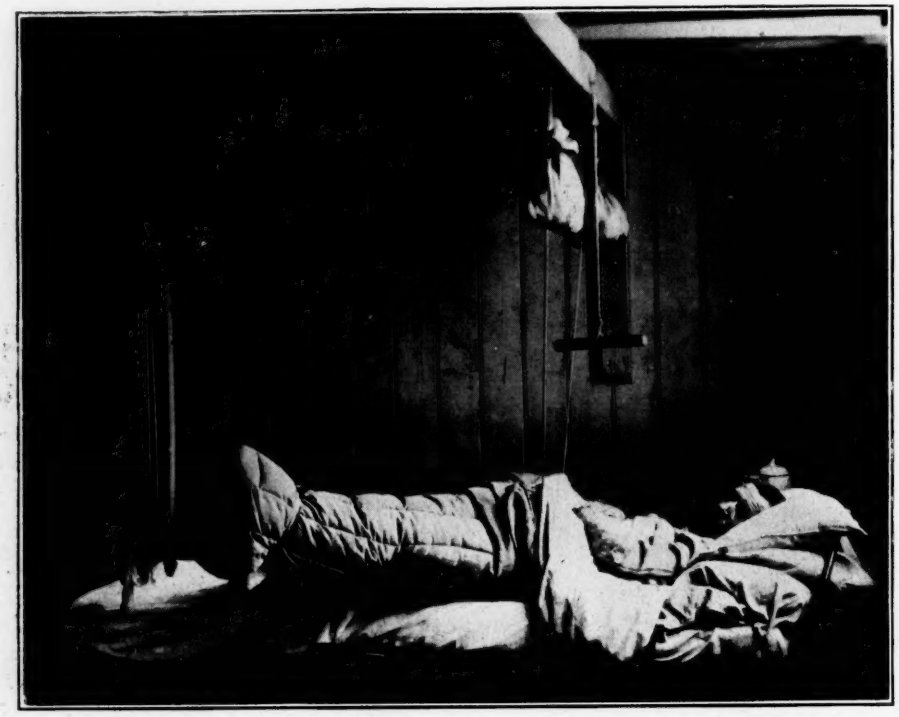


FIG. 322.—Alternative device for suspension of cases where two Thomas splints have been applied.

Treatment of Wounds.—When the dressing is to be done, the slings beneath the wound are unfastened, and it is cleaned up with alternate applications of hydrogen peroxide and saline. A small dry dressing is then applied, and clean sterile slings are fixed in position to the degree of tension required to maintain the corrected position of the fracture. When there is much discharge, the bulk of the dressing is placed outside the slings, and retained in position by a triangular bandage. Where acute sepsis is present, foments of saline or spirit are used. When the wounds have been efficiently cleaned up and effective drainage has been provided, this simple method, carried out as frequently as possible, has given better results than the application of one or other of the recently introduced antiseptics strongly recommended by others. Where wounds are extensive, the dressing is done in sections, so that all slings supporting the fracture are not withdrawn simultaneously.

Treatment Directed to the Fracture.—Within the first day or two, skiagrams are taken by means of the portable *x*-ray apparatus, and the necessary adjustments are performed in order to correct any deformity thereby shown. At periodic intervals further skiagrams are taken, and these give valuable information on the progress of the case.

MAINTENANCE OF EXTENSION.—Care must be taken that extension is efficiently maintained until firm union has occurred. Owing to the elasticity of the skin, and the stretching of the gauze strips by the continuous pull, the extension strips require frequent attention. Various devices have been described for maintaining the requisite tautness

of the extension strips without untying and retying them. Such are the key and screw thread described by Sir Robert Jones in the *British Medical Journal*, 1916, Dec. 16; the tie described by Rankin in the *British Medical Journal*; the twitch by means of a long nail; and the stout piece of rubber tubing attaching the strips to the end of the splint. Of these, the first has been found most suitable.

The extension required to correct the deformity in compound fractures is less than that in most cases of simple fracture; and in some cases of the former, lengthening of the fractured limb can be obtained by degrees of extension which are not excessive. The greater ease of correction of the deformity in compound fractures is due to two reasons: first, because, owing to the shattering and loss of bone at the site of fracture, there are not the same mechanical obstructions to reduction; and secondly, because the power of the muscles is diminished owing to their destruction and subsequent sepsis.

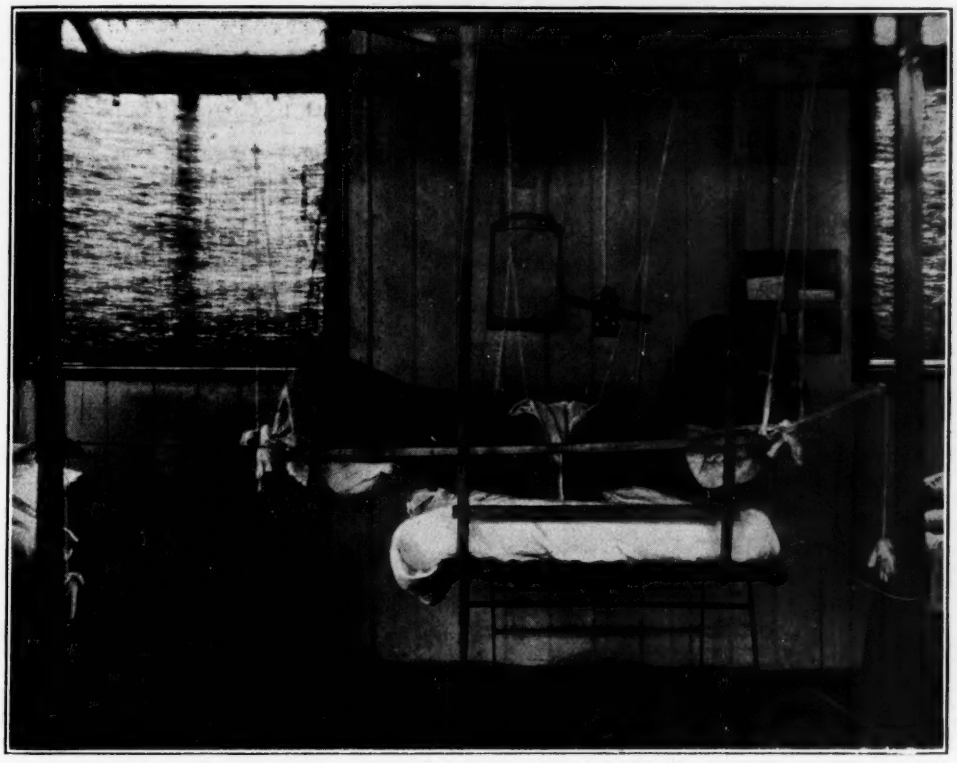


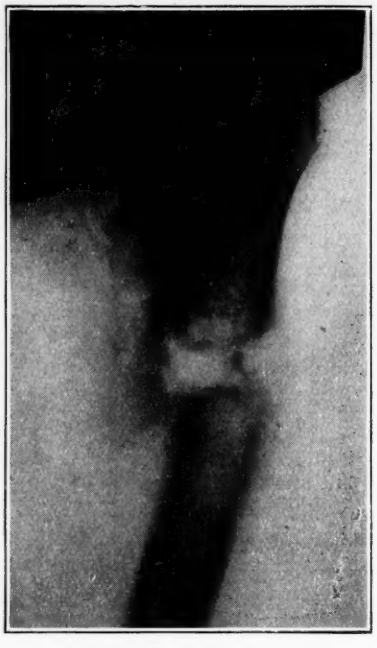
FIG. 323.—Showing extra abduction to correct deformity. Compare *Fig.* 318, showing ordinary abduction.

Lower Third.—In these cases direct lateral skiagrams of the fracture should be taken, to ascertain that the backward deformity remains accurately corrected; although usually when this has once been done, the deformity does not tend to recur as often as in other parts of the bone. Where the backward displacement of the lower fragment has not been entirely corrected, the following may be necessary: (*a*) Increased flexion of the knee; this is done by further bending the splint with a pair of wrenches. (*b*) Increasing the tension of the sling beneath the upper end of the lower fragment. (*c*) Additional extension; the extension exerted by the gauze strips may be supplemented by raising the foot of the bed and attaching weight-and-pulley extension to the end of the splint; this is rarely necessary.

The treatment adopted in those cases in which the knee-joint is involved will be discussed under "Complications."

Middle Third.—Antero-posterior and lateral skiagrams are taken. Even after the fracture has been accurately corrected, continual care is necessary during the whole of the after-treatment, in order that the normal antero-posterior curve of the femur may be maintained until firm union has occurred. In all cases of fracture the limb is frequently measured, to ascertain if shortening is present. The tape measure may show absence of shortening, and an antero-posterior skiagram good alinement, but there may be present a backward instead of the normal forward curve of the shaft. If union occurs in this position, the resulting disability is great. Good position can usually be maintained by regulating the tension of the slings supporting the fracture, but in some cases it may be necessary to exert additional traction on a fragment in a particular direction, e.g.: (*a*) Medially or laterally, by a sling passed round the limb and secured to the side-bar of the splint; (*b*) Antero-posteriorly or obliquely, by the arrangement shown in *Fig.* 320 (right thigh): an ordinary spring wire foot-piece is fixed to the splint near the knee; a straight metal bar is attached to this by one end, and by its other to the ring of the splint; the bar is fixed in the line in which it is desired to exert traction; the sling is passed round the limb and secured to this. This device can also be used in fractures in other parts of the bone.

Upper Third (*Figs.* 324–327).—Stereoscopic skiagrams are taken, as direct lateral views are not possible. As already stated, two Thomas splints are used to immobilize the pelvis as far as possible and to prevent its tilting when the fractured limb is abducted to correct the abduction deformity. On a single Thomas splint it is impossible to prevent the patient from altering the position of his body and pelvis, so defeating the efforts made to keep his fractured limb abducted. Where the skiagram shows that the initial abduction is insufficient, the fractured limb is further abducted as already described, and another skiagram taken. This is repeated until sufficient abduction has been obtained (*Figs.* 318, 323). It will be found in some cases that a greater degree of abduction is required in the earlier stages, as the abduction of the upper fragment may become less pronounced at a later date.



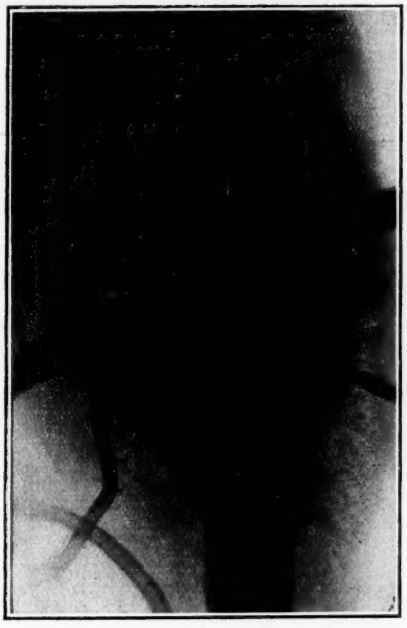
FIGS. 324, 325.—Fracture of upper third of femur, showing correction of abduction of upper fragment.

Where the skiagram shows that the upper fragment is still flexed in relation to the position of the lower fragment, the following may be necessary in addition to the measures already described: (*a*) Increased flexion of the splint at the knee; (*b*) Raising the level of the lower end of the splint.

As soon as reasonably firm union has occurred in cases where two splints have been applied, the splint is removed from the sound limb, and the fractured limb suspended by weights and pulleys as in cases where a single Thomas splint has been used from the

commencement. At the same time the splint is gradually straightened by means of a pair of wrenches.

Head and Neck.—The treatment of these fractures is the same as for those of the upper third, except that the splints are not flexed at the knee-joint. In six cases, septic arthritis of the hip-joint was associated with the compound fracture. The immediate prognosis in such cases is in marked contrast with that of similar infection of the knee-joint. All the cases met with subsided with immobilization and extension in the abducted position and free drainage. In two cases in which the head of the femur was completely detached, death of the detached head occurred, necessitating removal at a later date. Apparently, even in young men, in the presence of severe sepsis the vascular supply of the head via the ligamentum teres is insufficient to maintain its vitality.



FIGS. 326, 327.—Comminuted fracture of upper third of femur, with split down shaft (does not show well in reproduction). Gradual correction of deformity, with final union in good position. Hodgen splint to fractured side. Thomas splint to sound limb. See *Fig.* 317.

Position of the Foot.—This is kept at an angle of 10 to 15 degrees external to the sagittal plane, and at right angles to the leg. The foot is thus maintained in the normal position assumed in walking, and foot-drop is prevented. Where it is necessary to correct axial rotation of the upper fragment, the lower fragment may be externally rotated by increasing the angle made by the foot with the sagittal plane.

Pressure Sores.—The skin of the back and in the region of the ring of the splint requires careful attention, especially over the tuber ischii. Patients are also instructed that they themselves by gentle traction must frequently substitute another portion of skin between the tuber ischii and the ring of the splint. An air cushion has the disadvantage that the patient always tends to work it down between the ring of the splint and the buttock, and so to displace the ring from the tuber ischii. For this reason we have discouraged the use of air cushions as far as possible. With the limb in a flexed splint care must also be taken lest a sore result from continual pressure of a sling behind the knee.

Fracture Boards are inserted beneath the mattress from the pelvis to the head. Frequent changing of the mattress is necessary, as it becomes damp and mouldy on its under surface next the boards.

Covering of the Lower Limbs.—Special arrangements are necessary to keep the exposed lower limbs warm. Small woollen or eider-down quilts serve this purpose excellently.

Movements of Joints during the After-treatment.—It is stated that extension applied through the knee-joint for many weeks in cases of fractured femur is an important factor in causing subsequent stiffness and limitation of movement of the joint. Provided ordinary care is taken, we think that the fear of permanent disability from this cause has been overestimated. Observation of the cases of simple fracture of the femur in this series—all treated by the methods already described—has shown that in all these cases the limitation of movement of the knee-joint which is present when the limb is first removed from the splint, rapidly diminishes with massage and active movements.

In septic compound fractures the condition is more often due to the destruction and subsequent sepsis of the muscles and, to a less extent, of the other soft parts. When one observes the great initial loss of muscle—in many cases right down to the bone—the subsequent formation of inflammatory tissue as a result of sepsis, and the final fibrosis and scarring, one can readily appreciate the important effect these factors have on the subsequent movements of neighbouring joints. This is especially the case as regards the extensor muscles, with their wide origin from the shaft. In some cases the healed skin wound is firmly bound down by fibrous tissue to the subjacent bone, with no muscular tissue intervening. In such cases an attempt to increase the range of movement forcibly results in pain, located at the site of the original wound. In a few of our earlier cases forcible movement under an anæsthetic was performed. The results were not such as to lead us to continue the practice. In these cases, when all signs of acute sepsis had subsided and union was present, the thigh was immobilized as firmly as possible by bandaging in the splint and holding with the hand, and under nitrous oxide anæsthesia the knee was once flexed and fully extended. In two instances sepsis was again lighted up at the site of fracture, and in one, where the wounds were healed, the scar over the bone reopened. In none of them was the final result any better than would have been otherwise obtained.

The cases of permanently stiff knees become very few when one excludes those in which diminished range of movement at the knee-joint is due to: (*a*) Damage to the articular surface, either by fissuring into the joint, or by direct involvement in the wound; (*b*) Peri-articular infection, with fibrosis and scarring; or (*c*) Extensive damage to, and subsequent sepsis of, the muscles acting on the joint. Much of the disability which would result from the last class is obviated when free removal of devitalized and infected bone fragments by esquillectomy has been performed in the earlier stages of treatment, and sepsis of the fracture and muscles thereby diminished.

Our practice is as follows:—

Hip-Joint.—In cases on a single counterweighted Thomas splint, small degrees of movement take place at the hip-joint whenever the splint or patient is raised. After reasonably firm union has occurred, the patient is encouraged to sit up and move freely about the bed; free movement occurs at the hip-joint, and pressure is removed from the skin of his back. In cases where two Thomas splints have been applied, every few days the extension is removed from the sound limb, and the patient made to exercise freely all the muscles and joints. As soon as reasonably firm union has occurred, the splint is removed from the sound limb, the splint on the fractured limb is suspended by weights and pulleys, and the bed lowered.

Knee.—Every few days, after acute sepsis has subsided, the knee is gently moved as follows: A firm grip is taken of the condyles with one hand, and extension exerted. The extension strips are untied, and while the sister holds the splint and thigh at the site of fracture, the leg is gently raised from its flexed position on the splint to full extension. This movement is performed three or four times. The patella is moved as a matter of almost daily routine.

Foot and Ankle.—From the commencement the patient is instructed to perform each day a set number (e.g. 100) of movements of his foot and toes. This is readily

permitted on a Sinclair foot-piece when the tapes attaching it to the end of the splint are untied.

Massage.—Regular massage is carried out by masseurs in each ward.

COMPLICATIONS.

Sepsis.—Further incisions for drainage may be necessary on account of spread of infection causing collections of pus in various situations. The effect of gravity determines to a certain extent the direction of the spread. The commonest direction is up the posterior aspect of the thigh, may be as far as the buttock. Another frequent site is Hunter's canal; the spread is along the course of the femoral vessels, and the infection may spread from here into the region of Scarpa's triangle.

Operation for these conditions—and other secondary operations, e.g. the removal of sequestra—should, whenever possible, be carried out with a minimum disturbance of the limb, by simply removing the necessary slings. It is almost always possible to do this with the limb in the splint and the extension undisturbed.

Secondary Hæmorrhage.—This usually occurs from the 10th to the 20th day, but may occur much later. In one case it occurred twenty weeks after the wound, and was due to erosion of the popliteal artery on the posterior surface of the femur from a focus of infection around a sequestrum. In the majority of cases the site of the wounds and the severity of the hæmorrhage make it evident that the bleeding has occurred from the femoral artery. In these it is our practice to amputate rapidly at the site of fracture, because ligature of the femoral above and below the bleeding point in an already septic compound fracture is so frequently followed by gangrene, which necessitates amputation when the patient's condition is still more unfavourable. If the hæmorrhage has not been alarming, and from the situation of the wounds there is reasonable ground for believing that the bleeding is not arising from the main vessel, the wounds are explored. In some it is possible to identify the bleeding vessel and tie it above and below. In others no further hæmorrhage is seen when the tourniquet is relaxed. In the latter case the wounds are packed with gauze and the patient 'specialled.'

Blood transfusion has been employed in many cases of severe secondary hæmorrhage, and, in addition, is of value in patients who are profoundly anæmic from continued sepsis; in these the general condition is improved and the wounds take on a healthier appearance. The method employed is the indirect one, from vein to vein, by means of paraffin-coated glass flasks. Owng to the difficulty of obtaining Vincent or Kimpton-Brown tubes, we have used large Carrel ampoules with the ends suitably drawn, and have found them perfectly satisfactory. The amount given is from 600 to 900 c.c. *Group IV* donors have been used in all cases, and a few of these are always kept available. Prior to the adoption of blood transfusion, saline solutions were given intravenously, but the improvement in the patient's general condition is transient—not lasting, as in blood transfusion.

Infection of Joints.—In fractures of the lower third of the femur the knee-joint is frequently involved, either by the wound opening directly into the joint, or by a fissure extending from the site of fracture; these fissures may not always be evident in the skiagram. In the former, as already stated, the special treatment directed to the correction of the fracture is delayed until the fate of the knee-joint is determined, and absolute immobilization is maintained. If the knee is obviously infected, the joint is aspirated and the fluid examined. When the infecting organism is streptococcal (especially the long-chained varieties), the prognosis is worst, and ultimate amputation generally becomes necessary. The prognosis is better in cases of anaerobic and coccal infections, in which aspiration followed by washing out of the joint, or drainage by parapatellar incisions, may suffice.

Suppurative arthritis of metastatic origin occurred in six cases, and in one case its incidence in the knee-joint followed on the movement involved in manipulating and re-extending a malunited fracture of the upper third in which signs of acute sepsis

had subsided. The six cases were, shoulder 3, wrist 1, knee 1, ankle 1. In its insidious onset and comparatively favourable prognosis, suppurative pyæmic arthritis is in marked contrast to the septic arthritis resulting from involvement in the wound or from direct spread from the site of fracture. Immobilization and drainage sufficed in all cases. In addition to pyæmic joints, localized pyæmic foci may develop in other situations.

Œdema of the Limb.—Œdema of the leg, foot, and ankle may occur when considerable tension of the slings above the knee is necessary to correct the displacement in fracture of the lower third. The general œdema of the limb which sometimes occurs on its removal from the splint, after union has occurred, subsides in a few days with massage and elevation of the limb.

Tetanus.—Tetanus was met with in four cases. In one, symptoms developed on the eleventh day, and death occurred within thirty-six hours from generalized tetanus. In another, recovery from generalized tetanus occurred, but death took place from secondary hæmorrhage at a later date. In the remaining two the symptoms and signs were localized to the wounded limb, and both recovered. All four cases had received the usual prophylactic injections of antitetanic serum, and all were treated by large doses of antitetanic serum given intramuscularly.

Associated Nerve Injuries.—The only cases met with have been lesions of the sciatic nerve (6 cases), which is especially liable to injury in compound fractures of the upper third. In one case the sciatic nerve was completely divided on the side opposite to that of the fractured limb by a missile which had passed through both thighs; suture of the nerve was performed, but it is too soon to judge with what benefit. In the other cases of complete division of the nerve, varying lengths up to four inches had been lost, and in addition severe sepsis was present. Suture of the nerve was not attempted, beyond connecting the divided ends with catgut to facilitate the identification of the nerve at a possible subsequent operation. Union of the fracture is greatly delayed in these cases; and although the prospect of the patient ultimately having a useful limb is remote, amputation has not been performed on these grounds alone, in the hope that successful nerve grafting may be possible at a later date, or that, even if the limb has eventually to be amputated, it may be possible to do so close to the knee, after firm union of the fracture has occurred, and so give the patient a more useful stump than if amputation had been performed in the first place at the site of fracture, which is usually in the upper third.

In these cases the after-treatment is difficult, owing to the tendency to the development of trophic lesions, rendering extension difficult.

In two cases loss of function in the area of distribution of the external popliteal nerve occurred during the after-treatment, and was probably due to pressure by a sling on the nerve in its exposed situation below the head of the fibula.

Formation of Sequestra.—As previously stated, the formation of sequestra and persistent sepsis are less frequent when careful subperiosteal esquillectomy has been performed. As acute sepsis is so readily lighted up, much harm may be caused by premature surgical interference for the removal of sequestra. Such operations are performed only when it is fairly certain that the sequestra are free. The time at which this occurs varies considerably. It is rarely less than six weeks, but may be much longer, as in cases when necrosis of the ends of the main fragments takes place and the whole thickness of the shaft itself is cast off. The situation and extent of the sequestra are determined as far as possible by *x*-ray examination. The sinuses leading down to them are opened up, and they are removed with as little disturbances of the other tissues as possible. This can usually be done with dressing or sequestrum forceps. No curetting or chiselling of the bone or callus is performed, except in those cases in which it is necessary to enlarge the track leading to a centrally-situated sequestrum. These operations are always performed with the limb on the splint.

Foreign Bodies.—Where free drainage has been provided, no extended search is made at the original operation for foreign bodies shown by the *x* rays, unless they are large

or readily accessible. In the few cases in which persistence of a sinus is due to their presence, they can be readily removed at a later date, when the track leading down to them can be readily followed. This is much preferable to undertaking at the primary operation an extensive dissection for their removal, as large tracts of uninfected tissue may thereby be opened up to infection.

LENGTH OF TIME NECESSARY FOR FIRM UNION.

As the cases treated were all fit men of military age, the ordinary systemic causes of delayed union are of secondary importance. The main factors are: (1) The extent of the original loss of bone; (2) The degree of subsequent sepsis; (3) Accurate reduction of the deformity; (4) Complete division of the sciatic nerve.

In one case of simple fracture of the femur in the lower third, firm union in faulty position was present at the time of admission on the 25th day, and resisted all efforts at correction under an anæsthetic. In this patient there was also a simple fracture of the radius, with synostosis to the ulna in pronation. At an open operation to correct the latter, firm union was found to be present.

In compound fractures where the destruction of the bone has not been great and sepsis is slight, firm union results in 7 to 10 weeks. Union occurs more rapidly in the lower third than in the upper third, and slowest of all in the neck. In cases where the shaft of the bone has been completely destroyed for two to three inches, 15 to 20 weeks or longer may elapse before union occurs.

The proportion of cases in which non-union occurs is probably not greater than 1 per cent, it being of course understood that cases with total loss of the shaft of more than four or five inches have usually been amputated at a casualty clearing station. It sometimes happens that a case which is apparently firmly united when examined on the splint, shows evidence of yielding or bending of the callus when the splint is removed and extension relaxed. This is more likely to occur when the fracture has not been accurately reduced. Usually for the first few days after the extension has been removed the limb is retained in the splint by a bandage.

WALKING CALIPER SPLINT.

Unless military reasons prevent, each patient is retained until he has been able to walk comfortably for two or three weeks on a walking caliper splint (*Fig.* 328). For 10 to 14 days before the splint is fitted, the limb is allowed to rest free in bed supported between sandbags. During this period massage is carried out and the patient performs systematic movements.

Measuring and Fitting.—An ordinary Thomas knee-splint is taken, the ring of which fits the thigh closely. One of the stock sizes can generally be used, and the fit should be such that when the ring of the splint is pushed home against the tuber ischii the fingers can just be inserted between the thigh and the ring of the splint in front. A stock size can be readily altered if necessary.

FIG. 328.—Patient fitted with walking caliper splint.

With the splint accurately applied and firmly pushed home against the tuber ischii, and the foot at right angles to the leg, a point is marked on each side-bar at the level of the sole of the foot. A second mark is made on each bar 1¼ in. below this, and a third mark

1¼ in. below the second, and the bars cut through here. The cut ends of the bars are turned in at right angles at the second mark, so that they come into direct apposition. The patient is fitted with a pair of army boots. The heel of the boot on the fractured side is tunnelled obliquely from side to side. In this tunnel a metal tube is fitted which just admits the inturned ends of the side-bars. The obliquity is such that the hole on the outer side lies 1 in. in advance of that on the inner side. This ensures that the toes are turned out in walking. The heel of the boot on the sound side is built up 1 in., and transverse leather strips are fixed to the soles of each boot to lessen the risk of slipping. The limb is firmly supported in the splint by strips of perforated zinc and bandaging.

Care should be taken that weight is not transmitted through the patient's limb. This may occur from the ring of the splint slipping over the tuber ischii. This tendency

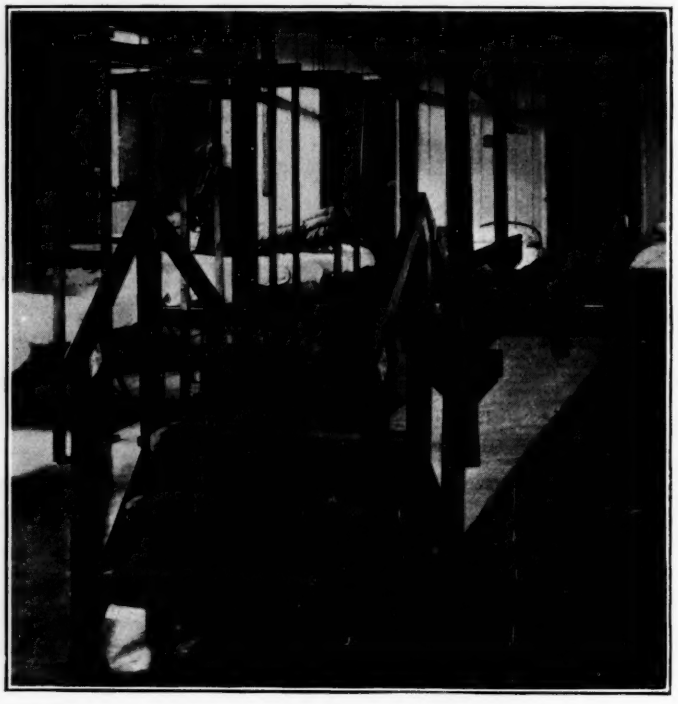


FIG. 329.—Track and steps for initial attempts at walking.

may usually be corrected by slightly flattening and turning over the padding of the ring in contact with the tuber ischii, so as to present a broader, flatter surface. In some cases the side-bars of the splint may be turned in 1 in. or even ¾ in. below the level of the sole of the foot.

Careful watch must be made that yielding of the callus does not take place during the initial attempts at walking. This is more liable to occur where union has taken place in faulty position, or where there has been considerable sepsis. In one of the wards a training track has been laid down, and on this patients make their first attempts at walking. On each side of a 10-yard strip of ordinary coir matting is a hand-rail suspended from the roof. The patient is thus able to practise walking himself without the aid of crutches or an orderly. There is also a small flight of matting-covered steps on which the patient practises going up and down stairs (*Fig.* 329).

THE OPERATIVE TREATMENT OF RUPTURED INTERNAL LATERAL LIGAMENT OF THE KNEE.

By Captain T. P. McMURRAY, R.A.M.C.

Alder Hey Orthopædic Hospital, Liverpool.

The internal lateral ligament of the knee is a large complex structure which forms the inner aspect of the capsule of the knee-joint, of which it is in reality only a thickening. It is usually described as consisting of two definite and distinct portions, a long outer or superficial portion, and a short inner or deep portion; but these two apparently separate structures are only different parts of the same ligament.

It consists of a large bundle of fibres which run from the femur almost vertically down to the tibia. The longer fibres are inserted at the femoral end into a small depression on the inner aspect of the femur just below the adductor tubercle, and at the other end into a wider area on the inner aspect of the shaft of the tibia about one inch below the level of the knee-joint. The deeper short fibres are inserted, like the superficial, into both the femur and the tibia, close to the articular edges of the bones, and in addition have an attachment to the flat inner surface of the internal semilunar cartilage. This attachment of the internal lateral ligament to the internal semilunar cartilage renders the ligament much more complicated in its structure and in its action than is the case with the external lateral ligament, which is only attached to the femur and to the head of the fibula, and has no attachment to the external semilunar cartilage.

In order to understand the action and injuries of the internal lateral ligament, it is necessary to comprehend clearly its structure and points of attachment, especially of the deeper portion, because on this depends largely the occurrence of complications in injuries of the ligament. The deep portion is attached above to the lower end of the femur and below to the upper end of the tibia, in each case close to the articular surface and in combination with the capsule of the joint. In its course it is attached, in association with the capsule, to the inner flat aspect of the internal semilunar cartilage; but the length of the ligament between its attachment to the femur and the cartilage is not the same as that between its attachment to the tibia and the cartilage.

The internal semilunar cartilage is closely bound down to the head of the tibia by its anterior and posterior cornua, and attached round its outer border by the capsule and by the internal lateral ligament, so that in any movement of the knee-joint the cartilage moves in conjunction with the head of the tibia, and only the very slightest amount of movement is present between these two structures, except in the case of an internal derangement of the knee-joint. Between the cartilage and the femur, however, there is movement on any change of position of the joint, so that the portion of the ligament between the femur and the cartilage must necessarily be longer than would be necessary to bridge the space between these two structures when the joint is at rest.

When the knee-joint is fully extended, both parts of the internal lateral ligament are tense, so that no lateral mobility can be obtained in the normal joint. If, however, the joint is flexed to any degree, lateral mobility can be obtained, and this yielding takes place in the internal lateral ligament above its attachment to the internal semilunar cartilage. Similarly, any strain of the internal lateral ligament—whether direct along the course of the fibres, following pressure applied on the outer aspect of the

knee, and so forcing open the joint on its inner side, or laterally by twisting of the joint—comes on the part of the ligament above the cartilage to a much greater degree than on that below.

The internal lateral ligament is usually injured in one or other of the above ways. Thus, a blow on the outer aspect of the fully extended knee may cause partial or, it may be, complete rupture of the ligament. When, on the other hand, the knee is flexed, direct violence on the outer aspect of the knee does not cause so great an injury as when the joint is extended, because the ligament is lax and can yield to the force further than when it is tense with the knee extended. When the ligament is injured with the knee-joint in the straight position, the rupture, whether partial or complete, almost always occurs between the attachment to the femur and to the internal semilunar cartilage, so that the cartilage, which remains closely attached to the head of the tibia, is never displaced by this injury.

On the other hand, a lateral twist of the joint, especially with the knee semiflexed, first puts tension on the upper portion between its femoral and semilunar attachments, and the lateral pull comes on the attachments to the cartilage and to the femur. With the knee straight, the strain on the ligament is taken by the femoral and the tibial attachments, but with the knee flexed, the lower part of the leg is at a different angle to the upper, and thus the strain comes entirely on the cartilaginous attachment. This is accompanied by a rotation of the femur on the tibia which tends to force the cartilage from its attachment; so that the result is usually a displacement of the internal semilunar cartilage, with or without a rupture of the internal lateral ligament.

In any case of injury or strain of the knee-joint, the history of the case, if carefully taken, will usually reveal in what direction the strain on the joint came, whether from the inner or outer side, and whether direct or associated with a rotation of the bones on one another.

Laxity or rupture of the internal lateral ligament is easily diagnosed by the power of abduction of the leg on the fully extended thigh, and if this is present, the history and clinical syndrome should be very carefully studied in order to see whether or not this rupture is associated with some internal derangement of the joint. It is frequently difficult to decide the point definitely, because in many cases, owing to the laxity of the ligament, a fold of capsule may become invaginated between the bones, and symptoms and signs very similar to those of a displaced cartilage are thus caused. When rupture of the internal lateral ligament exists, associated derangement of the knee-joint should only be diagnosed in the presence of clear and unmistakable signs of this derangement, because removal of the internal semilunar cartilage, which is frequently done in these cases, aggravates rather than relieves the condition.

Cases of rupture of the internal lateral ligament are frequently seen in our hospitals, both military and civilian, and varying treatments of the condition are given by different surgeons; but generally the result is not satisfactory, and some form of apparatus to support the knee-joint is usually applied either before or after operation.

The operation usually performed consists in shortening the ligament, with or without a pleating over it of the fascia covering the knee-joint. This operation often results in some temporary benefit to the patient; but the strain of body-weight which is constantly being thrown on the weakened ligament is usually sufficient in a few months completely to reproduce the laxity, rendering necessary some form of apparatus which will more or less perfectly support the inner aspect of the knee-joint.

It was in order to correct this unfortunate state of affairs that the following operation was devised in consultation with Sir Robert Jones, and it has now been performed by me in 10 cases with very satisfactory results and the complete removal of the necessity for any apparatus. These results have lasted in one case for twenty-eight and in another for twenty-five months.

The treatment given depends on whether the lesion of the internal lateral ligament is the only abnormality present in the joint, or whether there is in association

with it a displacement of the internal semilunar cartilage—that is, on whether the rupture of the ligament has occurred above or below its attachment to the cartilage. If there is no doubt that the latter has been detached from its insertion into the upper end of the tibia, it should first be removed through the ordinary antero-internal incision before the treatment of the ruptured ligament is attempted.

Before considering the operative treatment of the condition, it is necessary to fully understand the mechanics of the internal lateral ligament in its relation to the knee-joint and the variations of tension which it undergoes in different positions of the joint. When the knee-joint is fully extended (*Fig.* 330), all the fibres of the liga-

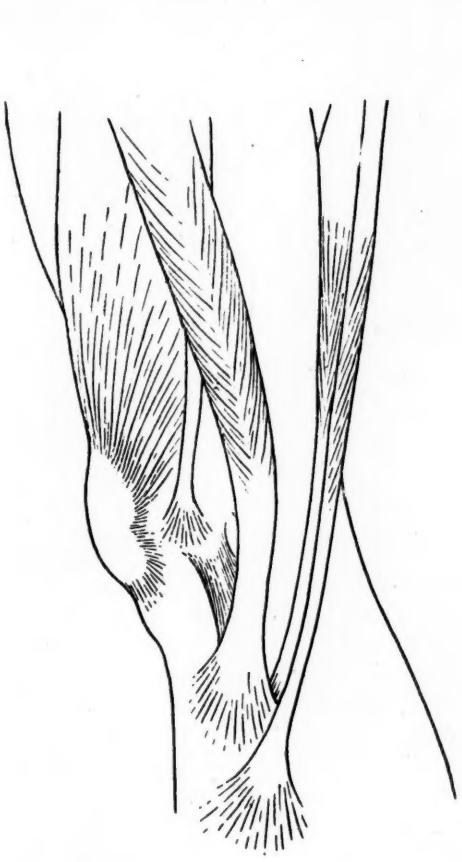


FIG. 330.—Showing the relation of internal lateral ligament to tendons on inner side of normal extended knee.

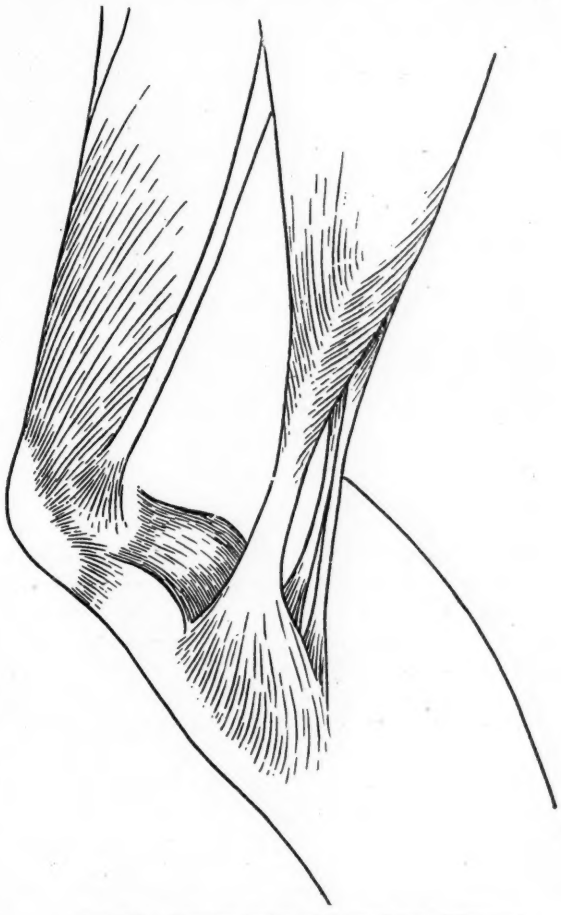


FIG. 331.—Showing laxity of internal lateral ligament caused by flexion of the knee.

ment are in tension, so that no abduction of the leg on the thigh is permitted in the normal joint. When, however, the knee-joint is flexed, the ligament becomes lax both in the superficial and deep portions (*Fig.* 331). The reason of this is that the distance between the femoral insertion of the internal lateral ligament and the lower articular surface of the bone is greater in the vertical than in any other direction, while on flexion of the knee-joint the femoral insertion is brought downwards and backwards, so that the distance between the femoral and tibial insertions is thereby diminished.

Operation.—This is performed with the leg lying on its outer side and the knee flexed to an angle of 35 or 40 degrees, so that the ligament is in the relaxed condi-

tion and can thus be more successfully tightened. A slightly-curved incision, convex posteriorly, is made from three or four inches above the adductor tubercle to one inch below the tibial insertion of the internal lateral ligament. The anterior flap is reflected forward, and this discloses all the structures on the inner aspect of the joint. Directly in the middle of the operation wound is the loose ligament, which can easily be demonstrated in its entirety. Lying slightly posterior to the joint, and held back by the fascia which covers it, is the sartorius tendon, lying close to the semitendinosus and gracilis. The fascia which secures the sartorius in its normal posterior position should be divided along the whole extent of the operative incision, so that the tendon can now be freely advanced (*Fig.* 332).

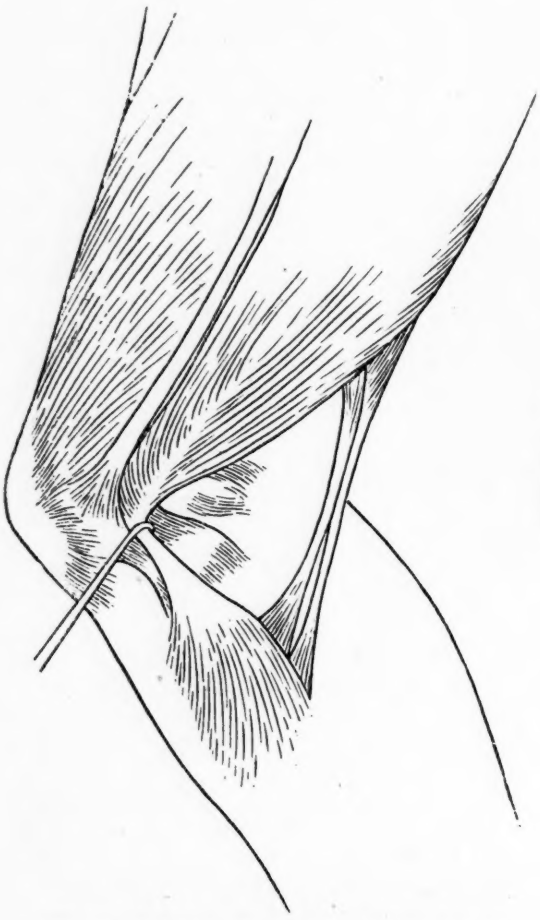


FIG. 332.—Sartorius tendon freed from fascia and brought forward over the internal lateral ligament.

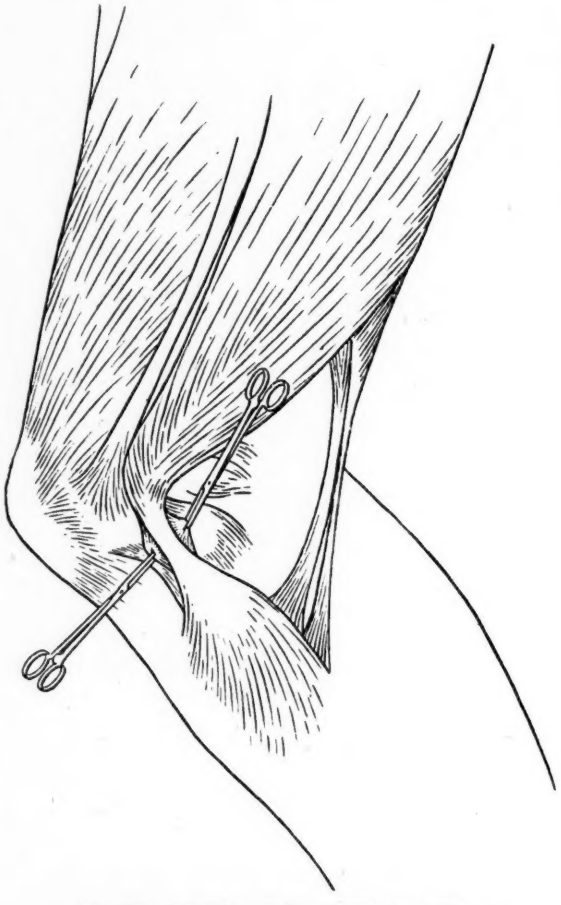


FIG. 333.—Sartorius tendon placed in position in groove in femur between the split upper end of internal lateral ligament.

The femoral insertion of the internal lateral ligament is now clearly defined, a vertical slit about one and a half inches long is made through it down to the bone, and through this slit a small vertical wedge of bone is removed from the femur, large enough to admit of the sartorius being placed into it (*Fig.* 333). This removal of bone is accomplished without interfering to any extent with the attachment of the ligament to the femur, so that no further weakening of the ligament is caused by it.

The sartorius tendon is now pulled forward and laid in the groove in the femur in such a manner that the portion of the tendon between the femur and the tibia is quite tight (*Fig.* 333), and it is then sewn firmly into the groove by stitches passing

through the periosteum and the ligamentous insertion. When this has been accomplished successfully, the outer aspect of the internal lateral ligament is first scarified, and then the ligament is tightened up in the usual manner by suturing adjacent portions of the scarified surface together.

The fascia is now sutured along the line of incision, and skin sutures complete the closure of the operation wound. The knee should then be retained in the semi-flexed position by means of splints or plaster for the next three months, when it will be found that full extension of the leg will be secured in the course of two or three weeks.

The success of the operation depends on keeping the knee in the flexed position during the whole course of the procedure, and the subsequent retention of this position during the minimum period of three months, in order to prevent stretching at the new insertion, which will undoubtedly occur if strain is allowed to fall on it before this interval has elapsed.

The operation results in changing the insertion of the sartorius from the inner aspect of the upper end of the tibia to the inner aspect of the lower end of the femur, and with an active quadriceps it interferes with no action of the knee-joint. The normal action of the sartorius is external rotation of the thigh and slight extension of the leg on the externally rotated thigh. This action is well seen in cases of infantile paralysis where the quadriceps is paralyzed but the sartorius is acting. On attempting to straighten the leg or the thigh, the whole leg and thigh are first rotated outward, owing to the position of the tendon of the sartorius, which lies behind the internal condyle of the femur and pushes this aspect of the lower end of the femur forward; further action of the muscle produces a very weak extension of the leg in this position. This action of the sartorius is duplicated by the external rotators of the thigh inserted into the great trochanter of the femur, and by the very much stronger extension action of the quadriceps. Indeed the power of external rotation of the thigh is in no degree diminished owing to the insertion into the inner aspect of the femur, so that the normal movements of the leg and thigh may be said to be left entirely as they were before.

A PROCEDURE FOR AVOIDING COLOSTOMY AND COLECTOMY.

By A. RENDLE SHORT, Bristol.

One of the commonest causes of acute intestinal obstruction demanding immediate operation is a carcinoma of the cæcum or colon. My procedure in dealing with such cases has changed more than once. There was a period when I performed a right colostomy or cæcostomy, unless the cæcum itself was involved. The only merit of this operation is the ease with which it can be carried out; it leaves the patient with what will often be a permanent artificial anus, which will be a perpetual source of annoyance to him. The great majority of these sufferers would far prefer the slight additional risk at the time of the operation involved in substituting short-circuiting for an artificial anus. My next procedure was to perform lateral ileosigmoidostomy with a Murphy button. This was often satisfactory, but by no means always so. In two out of three cases there followed great and lasting distention of the colon with gas and fæces, giving rise to much discomfort; and one patient died on the twenty-seventh day with gradually increasing distention and occasional vomiting in spite of regular evacuation of the bowels. The distention is no doubt due to the fact that gas and fæces pass the intestinal anastomosis into the cæcum, and are trapped between the ileocæcal valve and the cancer.

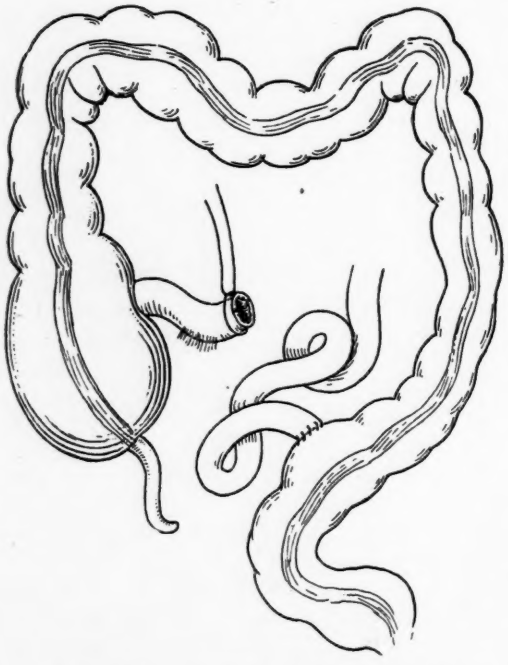


Fig. 334.—Diagram of end-to-side ileosigmoidostomy, with division of the ileum, the distal end being brought out into the wound.

This experience raised the question of an end-to-side ileosigmoidostomy, with division of the ileum. It is well known, however, that this is unsatisfactory, the colon and cæcum becoming filled with gas and fæces by retrograde peristalsis from the site of the anastomosis ('anastalsis' of American writers). I therefore determined to bring out the distal stump of the ileum in the wound, for two reasons: firstly, by passing a catheter through it into the cæcum, the gas could be drawn off; secondly, a wash out of warm water, containing an ounce or two of a magnesium sulphate mixture, could be given through the catheter, which would effectually clear the bowel (*Fig.* 334).

The technique, therefore, is as follows in a case of *Acute Intestinal Obstruction due to Carcinoma of Cæcum or Colon:*

1. Median laparotomy. Verify diagnosis.
2. Division of ileum about four inches from ileocæcal valve.
3. Incision two or three inches deep in mesentery of ileum. Hæmostasis.
4. Trendelenburg position.

5. Proximal end of ileum united by end-to-side anastomosis with Murphy's button to pelvic colon, as high as possible (without going too near the cancer).
6. Closure of abdomen in two layers; distal stump of ileum, with catgut ligature tied round the end, brought out in middle of wound.

If the omega loop of pelvic colon is long and large, the operation is rapid and easy, and the Trendelenburg position is not needed. If the cancer is within two inches of the reflection of the peritoneal floor of the pelvis from the front of the junction of pelvic colon and rectum, the operation is impossible. With the aid of the Trendelenburg position and Murphy's button one can make an anastomosis in many cases where the available pelvic colon is so low down and so tight that the operation would be impossible without their aid.

I am strongly prejudiced against the use of a Murphy button for a small-intestine anastomosis, because it may block the bowel when it passes on; also for a large-intestine anastomosis, because it may itself be blocked by hard fæces. Its use at an ileocolic junction is free from both these objections.

Some of my patients have been troubled with vomiting for two or three days after the operation; this may be relieved by giving pituitary extract or physostigmine salicylate, or by a dose of croton oil and a wash-out through the ileal stump into the cæcum in a really troublesome case. These methods were successful on each occasion. Most of the patients get a transient diarrhœa from deficient absorption of water in the pelvic colon and rectum. This is treated by a few doses of tincture of opium.

The ileal stump does not discharge provided the opening is flush with the skin.

After using the technique above described for patients with acute obstruction, I had a succession of cases in which abdominal exploration for grave symptoms (persistent pain and complete invalidism after appendicectomy; symptoms suggesting cancer of the colon; prolonged incessant vomiting; symptoms somewhat indicative of ureteral calculus) revealed the condition variously described as visceroptosis, chronic intestinal stasis, or cæcum mobile: that is to say, a marked ileal kink, with firm adhesions binding down the ileum a few inches from the ileocæcal valve, a very large, mobile, dropped cæcum, Jackson's pericolic membrane, sagging transverse colon, adhesions slinging up the pelvic colon, and movable kidney. There are grave objections to all the recognized methods of dealing with these cases. Ileosigmoidostomy alone leads to great trouble from retrograde peristalsis filling the colon and cæcum with gas and fæces. Colectomy is, except in the hands of one or two, a dangerous operation. Division of the bands is not curative, and may lead to fatal peritonitis from soakage through of intestinal bacteria. Cæcoplication succeeds well when only the cæcum is at fault, but not when the ileum, transverse colon, and pelvic colon are also involved. I therefore used the same technique which had served me so well in obstruction, except that, time being less urgent and abundance of pelvic colon available, I did not make the anastomosis by means of a Murphy button, but by suturing in the ordinary way over a rubber tube placed in the lumen to avoid kinking.

Three of the four cases appear to be completely relieved of their symptoms, and the fourth, though very neurotic and an invalid of many years' standing, is greatly improved. I promised in each case to close the ileal safety-valve in six months if desired, but it does not appear to give them much trouble.

I observed a day or two ago that a somewhat similar technique is employed by Ochsner in America, instead of colectomy.*

Brief notes are appended of the four cases in which the operation was performed for dropped dilated cæcum with ileal kink, to show the type of symptoms for which I have thought it worth while to operate. I do not advise this procedure merely for constipation, or for distant lesions attributed to toxæmia.

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* Ochsner, *Annals of Surgery*, 1917, October, p. 443.

Case 1.—Woman, age 39, sent by Dr. Barber. History of pain in right iliac fossa for nearly two years; has spent many weeks in bed for it. Appendix removed six months before admission without benefit (the appendix was practically normal, except that it was very slender). At the same time a Jackson's pericolic membrane was divided. There has been continuous pain ever since, with constipation, and patient is a neurotic bedridden invalid. Temperature 100·5°, pulse 144. Ileosigmoidostomy performed by technique described on April 12, 1917. Cæcum was very large and dropped into the pelvis; Jackson's pericolic membrane present; transverse colon sagged down into the pelvis.

At the present time patient is a great deal better, but still unable to do much work.

Case 2.—Man, age 48, sent by Dr. Hawkins. History of great loss of flesh (has lost 3 stone), colicky abdominal pain, and constipation, of some years' standing. Patient was much emaciated; visible peristalsis was present; there was no free HCl in gastric juice; bismuth skiagraphy showed general delay. Diagnosed as cancer of the colon. Explored March 26, 1918. No growth present, but cæcum large and dropped, Jackson's pericolic membrane, typical Lane's ileal kink, appendix slung up by a band.

At the present time patient is greatly improved, and has been free from all pain ever since the operation. At first it was necessary to wash out through the ileum, but not after he left the infirmary.

Case 3.—Man, age 37, sent by Dr. Fortescue-Brickdale. Patient was taken ill in February, 1917, and was invalided out of the Army for abdominal pain and vomiting. In July the abdomen was explored by a surgeon and nothing found. He has lost 3 stone in weight, and has now been vomiting every day for weeks in spite of all treatment, and his life is obviously in danger. No abdominal distention; gastric acidity normal; bismuth skiagraphy shows general delay. At operation on April 16, 1918, stomach and other organs were found normal, but cæcum was dropped and dilated, Jackson's pericolic membrane present, appendix absent, marked ileal kink by band two inches from ileocæcal valve.

The patient did excellently after the first few days, during which time it was necessary to wash through. Too much protruding ileum was left, and it had to be trimmed under novocain subsequently. There has been no return of the vomiting.

Case 4.—Woman, age 39, sent by Dr. Crossman. History of pain in the lower left abdomen two years, with constipation and loss of flesh. Has lost 1⅛ stone in eight months. Skiagram showed what was diagnosed as a ureteral calculus, though before seeing this I concluded that the case was one of visceroptosis. Both kidneys were mobile. On exploration, July 9, 1918, the 'ureteral calculus' proved to be a calcareous mesenteric gland. The pelvic colon was large, and slung up to the iliac fossa by a band of adhesions, dragging on which caused the pain. The cæcum was large and dropped. There was a well-marked ileal kink by band. The transverse colon was very low.

Patient's pain was immediately relieved by the operation, and has not returned.

DISPLACEMENT OF THE MANDIBULAR MENISCUS AND ITS TREATMENT.

By J. HOGARTH PRINGLE, Glasgow

Whilst the menisci of the knee-joint are a very frequent source of trouble, the articular disc of the mandibular articulation is so only on quite rare occasions. In consequence, the symptoms of the latter accident are probably not well known, whereas those of the former are very generally recognized, especially by the members of that class of the community which is particularly prone to be affected ; so much so, in fact, that I have now and then thought some of them not only made the diagnosis, but the symptoms as well, for purposes of their own.

I am driven to the belief that displacement of the mandibular disc is a rare accident, because, after personal experience of it on several occasions, I feel convinced that the discomfort, not to say the pain, caused by the occurrence is so extreme, that only the most casual individual would be content to 'carry on' without endeavouring to obtain relief in some way or other.

As in the knee-joint, so in the mandibular articulation, displacement of the meniscus is the result of some sudden movement of the joint, such as is constantly being made by everyone without any untoward effect ; so that the rarity of the accident in the one case compared with the other must be due to a large extent to the difference in the anatomical conformation of the two joints, putting aside such predisposing causes as may tend to loosen the cartilage.

In the knee-joint each meniscus is a crescentic structure placed at the periphery of a very shallow concavity ; while in the mandibular joint the meniscus is a dome-like, highly concave structure closely and accurately applied to the convexity of the condyle, which may be described as a segment of a cylinder having a quite short radius, and working in the hollow of a deep fossa. In Quain's *Anatomy* the disc is described as being "of oval form, broadest transversely, thickest posteriorly, and thinnest at its centre." This, however, does not appear to be an accurate description. Many years ago I paid a good deal of attention to this disc, and examined a large number in the dissecting-room ; and more recently my friend Dr. W. K. Hutton most kindly allowed me to see the mandibular articulation in a considerable number of subjects at Queen Margaret College. What I have invariably found is that there is a very decided central thickening of the disc, situated in its coronal plane over the summit of the condyle (*Figs.* 335, 336). In front of this ridge there is a distinct depression in the disc, which fits the tuberculum articulare of the temporal bone ; while below this and anterior to it there is a second thickening, which forms the anterior border of the disc and has the external pterygoid muscle attached to its lowest part (*Figs.* 336, 337). These two thickenings, with the intervening depression, give the superior surface of the disc its typical concavo-convex outline as seen from the lateral aspect (*Fig.* 335), fitting it accurately to the sinuous articular surface of the temporal bone. The posterior portion of the disc tails off from the thick coronal ridge, and lying in close contact with the posterior surface of the condyle, becomes lost in the fibrous tissues of the capsule of the joint.

The disc divides the joint into two cavities, each having its own synovial membrane. In a normal joint the condyle and the meniscus move together in all positions of the joint with a gliding movement which takes place in the superior synovial cavity ; whereas between the condyle and the disc itself a movement of rotation takes place in

the lower cavity. As a result of the presence of the two cavities the movements between the mandible and the temporal bone are rendered somewhat complex.

The most important relation of the disc, in view of its displacement, is that it has attached to its thickened anterior border a part of the external pterygoid muscle (*Figs.* 336 and 337). It is, I believe, due to overaction, or irregular action, on the part of this muscle that the disc gets dragged out of its normal position and the symptoms are produced. I call it 'out of position,' because it seems most improbable that any tearing of this disc can ever take place. Tearing or splitting of its tissue is quite commonly the cause of the symptoms that arise in connection with the medial meniscus of the knee-joint; but I do not know of any record of the mandibular disc having been either torn or split; the accident is almost invariably a displacement.

Method of Causation.—The accident is the consequence, in almost every instance, of a sudden and generally excessive action in closing the mouth, such as occurs in the free gratification of an inclination to yawn or sneeze; in a muscular action of this nature, the external pterygoid muscle may do just a little too much, and, as I suggest, drag the disc askew. It may be the result of a violent cough; it is certain that this can happen in the case of a person who has once had one of his discs loosened by a former accident. It

FIG. 335.—Lateral view of the mandibular condyle capped by its articular disc, to show the sinuous outline of the latter and its attachment to the external pterygoid muscle. × 2. (Drawn by Mr. A. K. Maxwell from a recent specimen.)

FIG. 336.—The articular disc has been divided in the sagittal plane, and one half of it removed to show the central and anterior thickenings and the depression between them for the tuberculum articulare. The attachment of the external pterygoid muscle to the anterior thickening of the disc is also shown. × 2. (Drawn by Mr. A. K. Maxwell from a recent specimen.)

can also be caused by a comparatively slight blow on the mandible while the mouth is open. The late Professor Annandale recorded one case produced during the act of vomiting. I have seen two patients who attributed their disability to violent tooth extraction under general anæsthesia.

Owing to the comparative rarity of these cases, one cannot say definitely what actually occurs when the disc is displaced; but from my own sensations I believe that it gets dragged askew—that it goes forwards and inwards, so that its thick central ridge becomes placed obliquely instead of lying in the coronal plane. What is certain is that after displacement the disc acts as a foreign body in the joint: either it gets caught between the rolling condyle and the tuberculum articulare; or it continues to move with the condyle, but in flexion of the joint the condyle and the abnormally-placed disc cannot now clear the articular eminence.

Under the term 'subluxation of the jaw,' Sir Astley Cooper described what appears to be the same condition. In his great *Treatise on Dislocations*, p. 393, he wrote, "as in the knee the thigh-bone is sometimes thrown from the semilunar cartilages, so the jaw appears to occasionally quit the interarticular cartilage of the temporal cavity, slipping before its edge and locking the joint with the mouth slightly opened"; and regarding

the treatment, he says, " Force for removing these appearances must be applied—to give an opportunity for the cartilage to replace itself upon the rounded extremity of the condyloid process." The disc, however, is so closely adapted to the outline of the condyle that it seems to me impossible that the latter could be displaced from it. A comparatively slight twist of the axis of the disc would bring the thick coronal ridge into such a position as would allow it to lock the joint, to the extent that the upper and lower teeth on the affected side could not be brought into contact so long as it remained in its abnormal position.

Symptoms.—When the accident occurs during the progress of a full and satisfactory yawn, for example, the approximation of the teeth proceeds violently and rapidly, and the displaced disc, by intervening between the moving condyle and the temporal bone,

FIG. 337.—Section through the left temporo-mandibular articulation, the mouth being partly open, to show the shape of the articular disc, and the attachment of the external pterygoid muscle to it.

suddenly and abruptly arrests the movement of elevation which the mandible is making at the moment ; closure of the jaws is prevented, and at the same instant the subject of the accident experiences the most acute pain in the region of the joint. The disc is severely crushed between the condyle and the temporal bone, and the tissues around the joint are much overstretched, precisely as occurs in a knee-joint when one of the menisci becomes displaced.

Having recovered from the initial surprise and pain, the patient discovers that if he attempts to close the jaws, the teeth on the affected side will not come quite together, and that any attempt to force them into contact is associated with severe pain at the joint, while there is a definite feeling of a something which prevents the joint from flexing completely. If the disc remains in its abnormal position, mastication is rendered difficult from the beginning, by the pain it induces as well as the mechanical obstruction

it causes. But while a person at the commencement of a meal has great difficulty and pain in chewing, the movements may gradually become easier and less painful, so that by the end of the meal he may possibly consider that everything is right. An hour or so later, however, the pain becomes as bad as ever, and is aggravated by any and every movement that may be made in the affected joint. The explanation is, I take it, that as mastication is persisted in, the disc becomes more and more compressed, only to expand again when the joint remains at comparative rest after the meal, when it can interfere once more with the movements of a joint now rendered tender from the traumatism to which it has been subjected during the process of mastication. Such a compression and expansion would be entirely analogous to that which takes place in the intervertebral discs as the result of the superimposed weight during the erect posture and its removal when a person resumes the horizontal position. Possibly the size and nature of the bolus of food may have something to do with this; a large and rather tough one, which prevents the complete meeting of the teeth in the first instance, may allow the process of chewing to proceed without much trouble, by permitting a gradual compression of the disc, and therefore a gradual approximation of the mandible to the maxilla; while a softer bolus would permit rapid approximation, and so induce more pain.

To a certain degree the pain on movement may be due to effusion into the joint cavities, but it is in the main caused by the stretching of tissues and the squeezing of the disc; the sensation is that of a foreign body which is preventing perfect closure of the jaws. No doubt effusion takes place to some extent, for the external surface of the joint becomes tender to the touch; but I have never been able to satisfy myself that any swelling was present.

In addition to immediate displacement and the rather characteristic symptoms associated with it, some patients are liable to a continually recurring displacement, which is not so acutely painful, but is yet sufficiently distressing; the disc, or disc along with the condyle, slips in and out of position, causing pain as it does so, while at the same time a snap or crack takes place in the joint which is audible to the patient, and sometimes to a bystander as well. This noise in itself may be a source of much annoyance to the sufferer.

Method of Reduction.—The first time I experienced the effects of the injury, the disc remained out of position for several days, during which time many fruitless attempts were made to reduce it. I managed in the end to get it back into position by keeping up hard pressure at the back of the condyle with the mouth open, and slowly closing the jaw. Since then I have always succeeded by the same process, although it sometimes requires to be repeated several times; the moment it succeeds, the sensation of a foreign body in the joint disappears at once.

I have seen four patients who suffered from a similar condition. Two were medical students, and they at once appreciated my explanation of their discomfort when I showed them how to get rid of it. The other two patients were young women whose discomfort resulted from the extraction of teeth under general anæsthesia. In one of them I was able to reduce the displacement, and—for a long period, at any rate—the patient remained free from recurrence. In the case of the other, whose condition was of longer standing, although I was able to effect a reduction by manipulation, the disc continued to slip, and her state was rendered so miserable in consequence that she consented to an operation.

In recurring cases, the tissues, ligaments, muscles, etc., around the joint probably become so relaxed that it is impossible to maintain the disc in position, and it 'comes out' whenever the patient opens the mouth widely. For these patients the only means of treatment is by operation.

The literature of this subject is meagre in the extreme; the only cases known to me are those recorded by the late Professor Annandale (*Lancet*, 1887, vol. i) and those mentioned by Professor Perthes in his valuable contribution to *Deutsche Chirurgie* on the "Injuries and Diseases of the Jaw," which appear to have been of this nature. No method of reducing the displacement by manipulation has hitherto been published to

my knowledge. Mr. Annandale's cases were both recurrent ones, and he treated them by operation, suturing the 'loose' disc to the periosteum; as far as I am aware, these are the only cases that have been reported in which operation has been carried out.

I have only seen one patient whose condition was sufficiently bad to warrant me in advising an operation. She was a domestic servant, age 20, and was first seen in May, 1910, complaining of pain and a loud cracking noise in the left mandibular articulation, both of which she attributed to the extraction of some teeth from the mandible at the beginning of that year. She often has difficulty in closing the teeth after experiencing this cracking sensation. The pain is associated with the cracking noise and is made worse by mastication. She says she feels that something 'comes out' in the left joint on these occasions, and that sometimes it 'goes in' quite suddenly, and then she is at once free from discomfort.

It was very obvious that some object was in an abnormal position in her left joint; the cracking sound she complained of could be distinctly heard when she closed her jaws, and the snap was associated with pain which made her wince. This noise, as a finger placed over her joint at once appreciated, was due to the fact that when she closed her jaws the left condyle of the mandible (or the condyle with its disc) 'jumped' some object immediately before the movement was completed. I was able to reduce the displacement in the manner already described.

She was seen again in June, 1911. The left joint had been giving her a great deal of trouble again, and causing much pain at times. The tendency for the disc to become displaced had become much greater, and it had caused her so great and frequent inconvenience that she had been obliged to give up her situation more than once in consequence, and it continually interfered with her taking food. She was quite willing to have an operation for the condition. She thought that her right joint had recently become affected in the same manner.

On June 12, I excised the disc of the left joint; it was remarkably loose, and could be dragged freely over the condyle in whatever position we placed the mandible. The joint surfaces of the bones did not show any abnormality as far as could be seen, and certainly nothing like what one would expect to see in an osteo-arthritis. She went out with the wound healed on June 26, and was seen from time to time up to May, 1913, when she said she was free from pain and inconvenience in the left joint, and could take food with comfort again; the right joint had only very occasionally given her any trouble since she was operated upon.

SECONDARY JEJUNAL AND GASTRO-JEJUNAL ULCERATION.

By GARNETT WRIGHT, Manchester.

The occasional occurrence of ulceration of the jejunum or the anastomosis after the operation of gastro-enterostomy is a serious drawback to an otherwise valuable operation, and this is especially so in view of the fact that the complication is usually more serious and entails more severe operative measures than the original condition for which the gastro-enterostomy was done.

I have met with three examples of the condition in the past twelve months, two in patients of my own, and one in the patient of another surgeon, and have been impressed by the gravity and intractability of this troublesome complication. In consequence, I have made a careful study of the literature, in the hope of arriving at the cause, in order to minimize the risk in the future.

My first case is a remarkable one, and worthy of record on account of a rare pathological lesion of the stomach, in addition to the secondary ulceration which followed a gastro-enterostomy.

Case 1 (No. 120*).—J. R. C., male, age 32, was referred to me by a medical colleague at the Ancoats Hospital in September, 1910. For eighteen months he had had pain in the right lower abdomen. The pain, which was of a dull, aching character, was practically continuous, though he had exacerbations from time to time. One such outbreak eight months before had lasted four days. There was no constipation. On examination of the patient, nothing was discovered except tenderness on deep pressure over the appendix.

First Operation, Sept. 5, 1910.—A diagnosis of chronic appendicitis was made, and laparotomy through a McBurney's incision was performed, a long appendix containing several concretions being removed. A red mass was observed in the centre of the abdomen, extending downwards into the pelvis. This was very vascular, and began to bleed when touched by the finger. Accordingly the McBurney's incision was closed, and the abdomen was opened in the middle line. The mass proved to be a large soft tumour occupying the greater part of the large omentum. It was continuous (by a pedicle about half an inch in diameter) with a tumour the size of a walnut in the greater curvature of the stomach. The vessels on the greater curvature were much enlarged to supply the tumour. These were secured on each side, and a wedge of stomach containing the tumour was excised. When the wedge was completed, it was found to extend entirely across the stomach. The tumour of the omentum and stomach was removed, and the divided ends of the stomach were united. The abdomen was closed, and the patient made an uneventful recovery.

The *specimen* removed consists of a portion of stomach, with a tumour originating in the submucous coat about the size of a walnut. The mucous membrane is intact over the tumour. This tumour is connected by a pedicle half an inch in diameter, running directly from the greater curvature (probably along a blood-vessel) to a large tumour seven or eight inches in diameter in the great omentum; attached to the lower end of this tumour is a cyst the size of a Tangerine orange. The hardened specimen has been sliced to show the naked-eye characters of the growth, which has the curious 'marbled' appearance seen in hypernephromata. Microscopically, the growth is an endothelioma.

The subsequent history of this patient is remarkable. He consulted me once or twice complaining of indigestion. The symptoms were chiefly pain coming on immediately after food, and sometimes relieved by food, and a great deal of acidity and heartburn. On questioning him later, it was found that he had had similar indigestion since boyhood, though this fact was not elicited at the time. He had no vomiting at all until early in 1916, when he began to suffer from vomiting of the obstructive type, viz., large quantities at a time, night vomiting, etc. He came to see me early in May, 1916, and a diagnosis of obstruction, probably at the site of the old operation, was made.

He was admitted to the Salford Royal Hospital, and radiographic examination by Dr. Bythell showed that the obstruction was at the pylorus.

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* The numbers in brackets refer to the *List of Cases* at the end of the paper.

Second Operation, May 6, 1916.—When the abdomen was opened, the stomach was found to be greatly enlarged, and the cicatrix of the previous transverse gastrectomy was clearly visible. There was a very tight stenosis at the pylorus, following the contraction of an ulcer on the upper margin of the duodenum, just beyond the pyloric ring. The contraction had spread in a curious V-shaped manner, isolating a small pouch of the duodenum. As there were some adhesions in the lesser sac, an anterior gastro-enterostomy was performed, a double row of continuous silk suture being used.

The patient made an uneventful recovery, and had complete relief from symptoms until October, 1916. Then he had a sudden acute pain in the abdomen, lasting a few hours. A few weeks later he had a similar slight attack of pain, and after that he began to have chronic pain in the abdomen. It was not related to food, but was brought on when he got into certain positions. For example, he always had pain when he lay on his right side. There was a well-defined tender spot over the left upper rectus muscle, just above the umbilicus. A diagnosis of jejunal ulcer was made, and as the symptoms persisted, I decided to operate.

Third Operation, Dec. 9, 1916.—There was an ulcer on the efferent loop of the jejunum, just beyond the anastomosis. This ulcer was adherent by a single adhesion to the anterior abdominal wall. When the adhesion was divided, the lumen of the bowel was opened, and presenting through the opening was the knot of a silk suture. The silk was removed and the ulcer was infolded, in the hope that it might heal when the irritation of the silk was removed. After recovery patient was dieted and given alkalies and pure olive oil in order to reduce the acidity of his gastric contents, as acidity was still a prominent symptom with him.

He remained free from pain until July, 1917, and then he began to have slight attacks of pain. He had arranged to come to see me again, when he suddenly perforated at his home in Leeds on Oct. 3, 1917, and was taken to the Leeds Infirmary and there operated on by Mr. Richardson, who sutured the ulcer. His pain still persisted, and he again had evidence of adhesion of the ulcer to the abdominal wall, viz., pain brought on by lying on his right side. I therefore advised him to submit to a further operation.

Fourth Operation, Nov. 29, 1917.—The ulcer, still situated in the same place, was again adherent to the anterior abdominal wall. The adhesion was divided, and the anastomosis was undone, the opening in the stomach being closed with two long rows of sutures. The affected portion of the jejunum was next excised, the ends being infolded, and a lateral anastomosis was made. A posterior gastro-enterostomy was then established in the ordinary way through the transverse mesocolon, catgut alone being used for both rows of sutures. The adhesions in the lesser sac were not so troublesome as I had feared at the original operation of gastro-enterostomy, and the operation did not present much difficulty. There was very little shock, and the patient made an excellent recovery.

At the present time (August, 1918) he is still free from symptoms.

This case gains additional interest from the fact that the patient had one of the rare external polypoidal tumours of the stomach. The origin of the tumour in this case was from the submucous coat; and though it was malignant in nature, the patient was free from any sign of recurrence at the last operation, seven years after its removal.

Case 2 (No. 121).—This patient is one on whom I operated for Mr. H. H. Rayner, whose notes on the case, before the man came under my care, are as follows :—

"I performed a posterior gastro-enterostomy—no-loop—on this man in December, 1915, for chronic duodenal ulcer, of which there was marked evidence at time of operation. Linen thread was used for the anastomosis (two layers). After a few months' relief, the pain and epigastric tenderness returned, and in consequence I explored his abdomen in September, 1916 ; marked induration about the gastrojejunal anastomosis was found, evidently due to ulceration. An anastomosis between the afferent and efferent loops of jejunum was effected, and in performing this a length of linen thread was observed hanging down from the previous anastomotic site. As soon as the man resumed an active life, his symptoms all returned, and this time were more intense and severe than before the first operation ; after examining him in September, 1917, I decided to undo the gastrojejunal anastomosis, and so shut the small intestine off from any direct communication with the stomach ; however, before the man could be admitted to hospital I left Manchester for service abroad, and Mr. Wright at my request kindly undertook the care of the man."

On Dec. 22, 1917, I operated on him in the Salford Royal Hospital. I found much thickening of the stomach and bowel at the anastomosis, and thickening and shrinkage of the transverse mesocolon. The anastomosis, which was contracted, was undone, and the defects in the stomach and bowel were closed. The old duodenal ulcer was excised by an elliptical incision, which was afterwards closed transversely. As there was no stenosis, no new short-circuiting operation was done.

The patient made an uneventful recovery, and is now free from symptoms (August, 1918).

Case 3 (No. 122).—A man, age 43, was under my care in Salford Royal Hospital in January, 1912, for a perforated duodenal ulcer. The perforation was sutured, the ulcer being infolded, and a no-loop posterior gastro-enterostomy was done, silk being used for both layers of sutures.

He remained well for two years, and then began to have pain coming on shortly after food. At first the pain was only slight, but it gradually increased in severity. At times he could get relief by taking a little warm milk, but this was not always so. He never vomited, and never had any melæna, but he gradually lost flesh, and his life was miserable on account of the constant pain.

He was re-admitted to hospital on April 24, 1918. His condition at that time was one of considerable emaciation, and he had very definite tenderness and rigidity of the left upper rectus muscle. Secondary ulceration was diagnosed, and on April 25 I re-opened the abdomen. There was much thickening of the stomach and bowel at the site of the anastomosis, and the mesocolon in the neighbourhood was also thickened. With considerable difficulty the anastomosis was resected, the defect in the stomach sutured, and the cut ends of the jejunum were united end-to-end. There were numerous adhesions from the old perforation, and the condition of the pylorus and duodenum could not be made out clearly; but it was decided not to do any short-circuiting operation, as the patient was not in a condition to stand it. The abdomen was therefore closed.

The patient made a good recovery, and radiographic examination later showed that there was no stenosis of the pylorus or duodenum, so that no further operative treatment is considered necessary. At the present time (August, 1918) he is free from symptoms.

The *specimen* removed shows secondary contraction of the stoma, with several ulcers situated exactly on the anastomosis. No silk was present, either in the ulcers or in the tissues. Microscopic examination failed to reveal any trace of either layer of sutures, so that both layers had evidently been cast off.

SITUATION OF THE ULCER.

Jejunal ulcers were classified by Paterson into two types according to their situation: (1) Gastrojejunal, when the ulceration was on the line of the anastomosis; (2) True jejunal ulceration. He drew a distinction in the etiology of these two types, stating that gastrojejunal ulceration is largely due to failure in operative technique, while the true jejunal ulcer primarily results from the action of non-inactivated gastric contents on the jejunal mucosa. Moynihan supports this view, which, however, I hope to prove later is only partially true.

The true jejunal ulcers are usually situated on the efferent jejunal loop, nearly always within a short distance of the gastro-enterostomy, but occasionally several inches away. In a fair proportion of cases they are directly opposite the gastro-enterostomy. Very rarely indeed they are in the afferent loop. In some cases multiple ulcers are present.

According to Paterson, about one-third of the ulcers are gastrojejunal, and the rest jejunal. The published reports do not state the exact situation very clearly in many of the cases, but from a study of these, I find that, out of 142 instances, the ulceration was of the gastrojejunal type in 63 (that is, 44·3 per cent); in 10 the ulcer was situated opposite the gastro-enterostomy; in 54 it was on the efferent loop; in 2 on the afferent loop; on 9 occasions there were multiple ulcers; and in 4 cases the site of the ulcer was not stated definitely. The incidence of gastrojejunal ulceration is therefore appreciably higher than was shown in the statistics of Paterson.

When we inquire into the influence of the type of gastro-enterostomy on the site of the ulcer, we find that the character of the operation was mentioned in 130 instances. In 72 cases after anterior gastro-enterostomy, the ulceration was jejunal in 43 and gastrojejunal in 29. On the other hand, in 59 cases following posterior gastro-enterostomy, the ulceration was jejunal in 28 and gastrojejunal in 31. This may possibly be due to the fact that physiological conditions play a greater part in the production of true jejunal ulcers than of gastrojejunal ulceration, and that it is probable that these physiological conditions act more powerfully after the anterior than the posterior operation.

PATHOLOGICAL ANATOMY.

Two clinical types are met with: (1) The acute perforating ulcer; and (2) The chronic ulcer. As in the case of gastric and duodenal ulcers, these two types merge into each other, the acute ulcers tending to become chronic, while perforation is not unknown in the chronic cases.

1. *The acute jejunal ulcer* resembles the acute ulcer of the stomach, and has a punched-out, round appearance. It rapidly spreads through the thin jejunal wall and

produces perforation and peritonitis. This occurred in 21 out of 74 cases of anterior gastro-enterostomy (28·7 per cent), and in 10 out of 61 cases of posterior gastro-enterostomy (16·3 per cent), so that perforation is definitely a greater risk in jejunal ulcer following anterior gastro-enterostomy.

2. *The chronic ulcer* has shelving edges, and sets up local peritonitis over it, the ulcer becoming adherent to surrounding structures, and in many cases producing a large inflammatory swelling. The course taken by these chronic cases differs according to the type of the preliminary gastro-enterostomy.

When this has been of the anterior type, the ulcer tends to adhere to the anterior abdominal wall, usually behind the left upper rectus muscle, and a large tumour is produced in this situation ; a process of chronic perforation ensues, the ulcer gradually perforating the abdominal wall, and finally producing an external fistula (as in Paterson's case). In one case the ulcer penetrated into the liver. Only in rare cases does the ulceration burrow its way into the colon and produce a fistula into this viscus ; in 21 cases of jejuno-colic fistula the preliminary operation was of the anterior type in 2 only, and in one of these the operation was done by the retrocolic route, thus bringing the anastomosis into the same relation to the colon as in the posterior operation.

Chronic ulcer following posterior gastro-enterostomy also leads to an inflammatory swelling, but this is not so evident clinically, because it is hidden behind the colon and mesocolon. Chronic perforation of the true jejunal ulcer into the colon may occur, the colon becoming adherent to the base of the ulcer, and the ulceration then extending into the lumen of the large bowel. When the ulceration is on or near the anastomosis, it extends into the mesocolon, which becomes much thickened, and both contract, pulling the colon down to the anastomosis, to which it adheres, a fistula being formed in the usual manner.

In the process of healing, or partial healing, of these ulcers, contraction and stenosis may ensue. In the case of true jejunal ulcer there may be a stenosis of the affected portion of jejunum, usually the efferent limb, the afferent limb being dilated and hypertrophied. When the ulcer is situated in the jejunum opposite the stoma, contraction may produce a spur in the jejunal loop, and in this way obstruction of the gastro-enterostomy opening may follow ; such a condition is described by Edington and Moynihan.

By far the commonest form of stenosis, however, is that which results from gastro-jejunal ulceration, which leads to narrowing of the gastro-enterostomy opening. In some cases this may be so extreme as to lead to complete obliteration of the stoma, and there is no doubt that the cases of narrowing and obliteration of the opening which have been reported after gastro-enterostomy are due to antecedent ulceration, and not to non-functioning of the artificial opening owing to patency of the pylorus, as was at one time suggested. It is a noteworthy fact that narrowing of the gastro-enterostomy has been observed in many cases of true jejunal ulceration, and by some writers this has been considered a causal factor in the production of the jejunal ulcer. It seems more likely that in these cases the same causes which produced the jejunal ulceration had also set up ulceration on the anastomosis, to which the contraction was secondary.

ETIOLOGY.

The etiology of this grave condition is a matter of first importance, as it is only by a correct appreciation of the causes that we can hope to minimize or avoid it. Paterson estimates the incidence of jejunal ulceration at 1·5 per cent ; and while one may think this an over-estimate, and there are no figures which allow of an accurate estimate, there is no doubt that it is sufficiently frequent to be a serious drawback to an otherwise valuable operation.

Age.—This is of no importance. The youngest case was two months old (Mickulicz). The oldest was 81. The majority of cases occur between the ages of 30 and 45, as one would expect, this being the period of life at which gastro-enterostomy is most frequently performed.

Sex.—As regards sex, there is a marked preponderance in the male sex. In 140 cases of active ulceration in which the sex was mentioned, 113 were males and 27 females. While it is true that gastric and duodenal ulcers are commoner in men than in women, this relationship is even more marked in the case of jejunal ulceration. Thus, W. J. Mayo[1] had 154 gastric and duodenal ulcers in men to 46 in women. In dealing with duodenal ulcers alone, however, he had 83 men to 17 women, the proportion of males thus being even higher than in jejunal ulceration. It would seem that, even taking into consideration the greater frequency of operation for gastric and duodenal ulcer in males than females, the incidence of jejunal ulcer is rather greater in the former. Probably this is due to some physiological factor, as in the case of duodenal ulcer.

Type of Preliminary Operation.—When we study the cases of active ulceration, excluding the doubtful cases and the cases of simple stenosis without active ulceration, we get the following statistics as to the preliminary operation :—

Anterior gastro-enterostomy	38
Anterior gastro-enterostomy with entero-anastomosis ..	26
Anterior gastro-enterostomy en Y	10
Posterior gastro-enterostomy	54
Posterior gastro-enterostomy with entero-anastomosis ..	3
Posterior gastro-enterostomy en Y	5
Partial gastro-enterostomy	2
Not definitely stated	7

Thus, the preliminary operation was of the anterior type in 74 cases and the posterior type in 62; and when we consider that the posterior operation must have been done much more frequently than the anterior, it is evident that there is a greater liability to this complication after the anterior than the posterior operation. At first sight this inequality would appear to be greater than it really is, but further examination reveals the interesting fact that in a large proportion of the anterior cases—36 out of 74—the operation has been complicated by an entero-anastomosis or has been of the Y type. We shall see later on that this has an important bearing on the production of jejunal ulceration. Of the 62 posterior operations, only 8 were en Y or with entero-anastomosis. Jejunal ulcer, therefore, followed only 38 cases of uncomplicated anterior gastro-enterostomy, while in 54 cases it followed uncomplicated posterior gastro-enterostomy. It is, of course, impossible to estimate the relative number of anterior and posterior operations which have been performed to the present date; but the posterior operation must have been carried out much more frequently than the anterior, and the inference may be drawn that jejunal ulceration is commoner after anterior than posterior gastro-enterostomy, though possibly the noxious influence of the anterior operation has been overestimated in the past.

In 139 cases where the type of the preliminary operation is given, in 44 it was en Y or with entero-anastomosis. This is relatively a very high proportion, and well illustrates the influence of these proceedings on the production of jejunal ulceration. It is significant that no case of secondary ulceration has been reported after the operation of gastro-duodenostomy.

Exciting Causes.—When we come to consider the actual, as opposed to the predisposing, causes of jejunal ulceration, we find that they can be divided into two groups: (1) Physiological; (2) Errors in technique.

1. *Physiological.*—This group, in effect, means the action of the gastric juice on the mucous membrane of the anastomosis or of the jejunum, and it almost certainly has an effect in all the cases of ulceration, even when it is not the sole cause.

Paterson and other writers lay great stress on the effect of increased acidity of the gastric contents, maintaining that a high acidity injures the mucosa and allows the digestive action of the gastric juices to come into play. In a number of cases hyperacidity has been noted, and it seems likely that this condition increases the liability to ulceration, though the experimental work of Wilkie did not support this view. The hypothesis is further supported by the fact that only one case is reported as following operation for gastric carcinoma, and in that case there was probably a septic element, as the ulcers were

multiple and appeared within a short time of the operation. It is notorious that the acidity of the gastric contents is lowered in carcinoma, and therefore we would expect these cases to remain free from jejunal ulceration if this is caused by the action of the acid gastric contents. Further confirmation is found in the fact that after operations en Y and with entero-anastomosis we find a higher proportion of jejunal ulcer. After these operations the alkaline pancreatic and intestinal secretions are deviated from the anastomosis and a portion of the jejunum, and therefore unneutralized gastric contents come into contact with a mucous surface which is not accustomed to the action of an acid digestive fluid, and ulceration is easily set up.

On the other hand, there are records of cases of jejunal ulcer where the examination of the gastric contents has revealed no hyperacidity, and even diminished acidity. Probably, therefore, the action of the gastric contents depends on their digestive properties and not on hyperacidity, but the latter increases the activity of the former. This digestive action is brought into play by one or both of two factors : (*a*) The inability of the jejunal mucosa to withstand a digestive action to which it is unaccustomed ; (*b*) Local injuries of the mucosa.

a. The inability of the intestinal mucosa to withstand peptic digestion probably increases from the pylorus onwards, and this would explain the greater frequency of jejunal ulceration following the anterior operation. In this connection an interesting suggestion has been made by Dervaux—viz., that the lower we descend in the intestine, the less secretin is produced, and therefore the less secretion of pancreatic juice takes place. In other words, the chemical reflex producing the secretion of pancreatic juice is lessened in intensity, and this is more marked in cases of anterior than posterior gastro-enterostomy. The neutralization of the gastric contents is therefore less perfect in these cases, and the production of jejunal ulceration is favoured.

b. As we shall see later, errors of technique have more say in the production of gastro-jejunal ulceration than in the case of true jejunal ulcers ; and it is interesting to observe that, in 72 cases following anterior gastro-enterostomy, true jejunal ulcers were present in 43, gastrojejunal ulceration in 29 ; while in 59 cases after the posterior operation, true jejunal ulcers were seen in 28, and gastrojejunal ulceration in 31 ; showing the greater physiological liability to ulceration after the anterior than the posterior operation.

2. *Errors in Technique*.—These play an important part in the production of jejunal ulcers, and it is by a careful study of them that we may hope to lessen the incidence of the condition. Of prime importance is the method of effecting the anastomosis.

In 14 cases in my series this had been accomplished by means of a Murphy's button or bobbins. The Murphy's button produces a line of necrosis which must heal by granulation, giving a favourable opportunity for the gastric contents to act. Further, both buttons and bobbins are foreign bodies of a hard nature, which can easily injure the mucosa away from the suture line, allowing access of the gastric juices to the injured tissues.

The usual method of union is by a double row of continuous sutures, and for the most part an unabsorbable material such as silk, linen thread, or Pagenstecher thread has been employed. There is a gradually increasing body of opinion that it is the presence of such an unabsorbable suture that is the cause of secondary ulceration, particularly of the gastrojejunal type. The earliest instance in which this was observed was the case of Professor Berg (No. 62). Van Roojen also published a case (Berindina M.), but quotes the case of Battle (No. 13)—where a silk thread was present in the gastro-enterostomy opening, while the ulcer was 1½ in. below—as proving that such a thread may be harmless. We shall see shortly how this may be explained differently. In my list I have records of 13 cases in which the silk suture undoubtedly played an important part in the production of the ulceration (Nos. 13, 48, 62, 100, 107, 111, 112, 113, 115, 116, 117, 120, 121) ; and it is noteworthy that, since attention has been directed to this point, the condition has been reported with increasing frequency.

The harmful effects of the unabsorbable continuous suture may be produced in various ways. An infected suture may produce ulceration on the anastomosis, primarily of an acute infective character, which later on becomes chronic owing to the digestive action

of the gastric contents. Again, a sterile suture may, as it becomes loosened, tear out of the anastomotic ring, and produce a lesion which allows the digestive action to commence. In either of these two ways gastrojejunal ulceration may be set up. True jejunal ulcer may also arise as the result of the presence of such a suture. In my own case (No. 120), the ulcer was about half an inch beyond the anastomosis, and undoubtedly arose from the injury inflicted on the mucosa by the knot of the silk suture which was becoming loosened. The passage of the stomach contents waves the loosened suture about and rubs it against the jejunal mucosa, abrading this and leading to ulceration. It is not difficult to imagine a similar process occurring somewhat further down the jejunum, when the stitch has become almost entirely free, but is still attached at the lower angle of the gastro-enterostomy opening. This theory is in accordance with the usual situation of jejunal ulcers in the efferent loop, as the flow of the gastric contents would naturally carry the thread in this direction. It is quite easy to see that this may have been the origin of the ulceration in many cases where no suture has been found at the secondary operation, because the cases are not usually operated on until some considerable time has elapsed after the onset of the ulceration, and in the meantime the suture may have finally broken loose and disappeared.

When the harmful effects of the continuous unabsorbable suture were first recognized, it was thought to overcome this by the use of catgut for the inner layer of sutures. This is not sufficient to prevent jejunal ulceration, as is shown by the case reported by Barling (No. 145), where catgut was used for the inner layer and thread for the outer layer. It is proved by various observations that the outer layer of suture material can work its way into the lumen of the intestinal canal. Thus, in Wilkie's experiments, in his sixth series a posterior no-loop gastro-enterostomy was done, using catgut for the inner layer and silk for the outer. The animal was fed on hard meat and acid (through a stomach tube), and killed on the seventh day. There was a gastrojejunal ulcer with the silk outer suture projecting from it. A very important case also was reported by Woolsey,[2] where posterior gastro-enterostomy was done for duodenal ulcer, catgut being used for the inner layer and thread for the outer layer of sutures. Symptoms recurred one year and eight months later, and a second operation was undertaken two years after the primary one, when no ulceration was found, but the linen thread was seen hanging in loops inside the gastro-enterostomy opening. Removal of this thread cured the symptoms. In my own case also (No. 120), at the last operation no more silk was encountered, though two rows of silk were used for the anastomosis, the presumption being that the inner layer of sutures had been shed harmlessly, and that the outer layer was the one producing the ulceration. Pool,[3] again, reports two cases where posterior gastro-enterostomy was done, catgut being used for the inner and linen thread for the outer layer. Both were operated on six months after the primary operation, and in each case an ulcer was present on the jejunal side of the anastomosis, with thread in the bottom of the ulcer, in one case a knot lying there.

It is quite consistent with this theory that the ulceration may not appear for several years after the preliminary gastro-enterostomy. So long as the unabsorbable suture is *in situ*, it is a potential cause of harm. In fact, it probably is when it begins to loosen and be cast off that the mischief arises. Records are not wanting to show that such a suture may remain for several years. Thus, Delbet[4] mentions a case of pylorectomy with posterior gastro-enterostomy where a silk suture was passed three years after operation. Ricard[5] mentions a case of silk in a gastro-enterostomy one year after operation. In the case of Woolsey referred to above, the thread was still present two years after operation.

Various other errors in technique have been suggested as playing a part in the production of jejunal ulcer. Mayo records a case (No. 108) where a hæmatoma in the mesocolon produced by a needle prick was followed by a jejunal ulcer close to the anastomosis. The ulcer penetrated the whole thickness of the jejunum, the base being formed by the mesocolon, which was adherent at the site of the old hæmatoma. While it is difficult to see how a hæmatoma external to the bowel could lead to ulceration inside,

one could readily imagine that extravasation between the mucosa and muscular coats of the stomach and jejunum might lead to ulceration. This condition occurs when the hæmostatic stitch is not efficient, and also in cases where the inner layer of sutures is taken through the mucosa only.

The pressure of clamps has been suggested as a cause, but there is no evidence in support of this, and the same may be said of the theory of diminished blood-supply due to arteriosclerosis or to kinking of blood-vessels.

In a few cases an acute septic infection is probably present—viz., where the ulcers are multiple ; and it is noteworthy that in the few recorded cases of this type the onset of the ulceration has been rapid.

Delayed healing of the anastomosis, and consequent ulceration, may sometimes be due to injudicious feeding of the patient in the early days of the operation. The experiments of Wilkie support this view.

I would summarize my views on the causation of jejunal ulcer as follows :—

1. Jejunal ulcer is due to the digestive action of non-inactivated or imperfectly inactivated gastric contents on a mucosa which is not accustomed to withstand gastric digestion.

2. Such digestive action is more powerful when hyperacidity is present.

3. The lower in the intestine we go, the more powerful is the noxious influence of the gastric contents.

4. To enable the gastric digestion to come into play, some local injury of the mucosa is for the most part necessary. In the great majority of cases this is produced by the presence of a continuous unabsorbable suture, or by the presence of Murphy's button or some kind of bobbin.

5. In a few instances ulceration may occur as the result of the action of gastric contents without the help of any local injury. This is supported by the fact that jejunal ulcer can appear independently of gastro-enterostomy, as described by Schmilinsky.[6]

CLINICAL PICTURE.

The clinical picture in these cases varies according to the stage of the ulcer and the type of the original gastro-enterostomy.

Pain is the commonest symptom of all, and is present in nearly every case, the only exceptions being a few cases of perforation which have come on without any preliminary symptoms. The pain varies in character, sometimes suggesting a recurrence of the original ulcer after operation for duodenal ulcer, but it is noteworthy that in many instances the pain has no relation to the ingestion of food. Sometimes it is undoubtedly due to adhesions of the ulcer to the anterior abdominal wall. This was so in *Case* 1 (No. 120). Here the pain could always be brought on by the patient lying on the right side, a position which dragged on the adhesion of the ulcer to the abdominal wall. Where the original operation has been of the posterior type, adhesions to the posterior abdominal wall may be set up, in which case the pain will strike through to the back.

Vomiting is not common unless obstruction be present, either from stenosis of the stoma, spur formation in the jejunal loop, or annular stenosis of the jejunum.

Hæmatemesis and *melæna* are rare, but have been noted on several occasions. Acid risings and heartburn are not uncommon.

Local tenderness is usually present, and as a rule the tender spot is under the left upper rectus muscle. This tender spot may be quite definitely localized, or, where much tumour formation has occurred, it may be more diffuse.

Rigidity corresponding to the tenderness is usually found.

A local swelling can usually be detected under the left upper rectus muscle in cases following anterior gastro-enterostomy. Such a swelling is more difficult to feel after the posterior operation, even though considerable tumour formation exists.

When a fistula into the colon becomes established, a very definite train of symptoms follows. There is rapid and extreme emaciation, diarrhœa of the lienteric type, with

urgency of defæcation. Vomiting is present in a large proportion of cases, and the vomit is foul-smelling and contains fæces. Should there be no vomiting, there will probably be eructations of foul-smelling gas. The diagnosis can be confirmed by the recovery of fæcal matter from the gastric lavage and by radiographic examination.

Perforation leads to the usual symptoms of that condition.

TREATMENT.

The treatment of jejunal and gastrojejunal ulceration falls under two headings: (1) *Preventive*; and (2) *Curative.*

1. **Preventive.**—Under this heading come the technique of the preliminary gastro-enterostomy and the after-treatment of the patient. Needless to say, scrupulous care in aseptic technique is necessary to avoid any element of sepsis, and in cases where stenosis is present it is important to secure as clean an operative field as possible by a course of gastric lavage and by preliminary attention to the mouth and teeth. Gentle handling of the parts during the anastomosis, care in the application of clamps, and careful application of the inner hæmostatic stitch are all of the first importance; this stitch should be through all the coats, and not merely take the mucosa. Care should also be taken to avoid any tension on the mucosa, and for this reason I think the plan of excising mucous membrane is a mistake.

The anastomosis should always be by suture, and never by means of Murphy's button or bobbins. The suture material should be absorbable for both layers if a continuous stitch is employed. The Mayos use a continuous catgut stitch as the hæmostatic suture, and interrupted silk stitches for the outer layer, and in this way lessen the risk of jejunal ulceration. Since my case occurred, I have used continuous catgut sutures for both layers, using No. 0 catgut hardened in formalin and sterilized by the watery iodine method. At first I thought there was a risk of the catgut being absorbed too quickly and the anastomosis giving way, but I have now used this method in many cases without any trouble. Gronnerud[7] successfully used No. 1 pyoktanin catgut exclusively in 140 gastro-enterostomies, so we may consider that catgut may be relied upon to hold sufficiently long.

In closing the hole in the mesocolon after posterior gastro-enterostomy, the meso-colon should be sutured to the stomach well away from the line of the anastomosis, as recommended by the Mayo brothers. Should the patient be so unfortunate as to develop a jejunal ulcer afterwards, it will then be much more accessible.

In the after-treatment of these patients we should beware of allowing solid food too early. Wilkie's experiments showed clearly the evil effects of the trauma of lumps of meat on the healing gastro-enterostomy opening. At least a week should elapse before solid food is given, in order to allow the opening time to heal. It is important also, as Paterson has pointed out, to insist on care in the diet of these patients for a long time after operation, and to take steps to treat any increased acidity should such be present.

As regards the choice of operation, everything is in favour of the modern no-loop gastro-enterostomy with a wide opening. Theoretically, gastroduodenostomy is to be preferred, as no case of secondary ulceration has been reported thereafter. Practically, however, this operation has its dangers, especially the serious one of acute dilatation of the stomach. Gastro-enterostomy en Y and with entero-anastomosis should be avoided, the clinical evidence being strongly in favour of the influence of these operations on the production of secondary ulceration.

2. **Curative.**—When secondary ulceration has appeared, the question of treatment by medical or surgical means arises. Paterson advises a preliminary course of medical treatment—by rest in bed, rigid dieting, and the administration of alkalies—in the hope that this may cure the ulcer, or, failing that, may reduce hyperacidity and give surgical measures a better chance of success. This should be done as soon as any pain appears; but such a course of treatment should not be persisted in for any length of time, as there is no doubt that surgical treatment is infinitely easier in the early stages before extensive adhesions have formed.

It is true that in the series of published cases secondary operation has had only a very moderate success, and has in some cases failed dismally. In very many cases also more than one intervention has been necessary before a successful result has been obtained. Thus, in 145 proved cases, 19 died without any operation being performed; in 93 only one intervention was made; while in 26 two, in 5 three, and in 2 four interventions were necessary. When we study the end-results we find the following: deaths, 38; no relief, or incomplete relief, 25; well at the time of the report, 82. The number of cases reported cured is probably exaggerated, as many of the reports are dated a few months after the operation.

The results of surgical treatment so far can only be regarded as unsatisfactory, and it is probable that this is so because the etiology of the condition is not fully understood. It is a remarkable fact that many of the secondary operations have resulted in a gastro-enterostomy en Y or with entero-anastomosis, types of operation in which secondary ulceration is especially prone to happen. Further, we find that Murphy's button has been used occasionally in a secondary operation, and probably silk or thread sutures have been invariably used. I regard the use of absorbable catgut sutures as a matter of the first importance in any secondary operation which is undertaken.

Where the preliminary operation has been an anterior gastro-enterostomy, with or without an entero-anastomosis, the gastro-enterostomy opening should be undone—the opening in the stomach being closed in the usual way, and the small intestine being restored or closed as may be indicated. When pyloric stenosis is present, a large no-loop posterior gastro-enterostomy opening should then be made, *catgut alone being employed for the anastomosis*. If the pylorus is patent, and the original lesion cured, we are faced by a more difficult problem, but here again the gastro-enterostomy should be undone. This will often necessitate resection of a portion of the bowel and of the stomach wall. The opening in the stomach should be closed as usual. If possible, the opening in the jejunum should be sutured transversely. If this is not possible, the upper end of the bowel should be implanted into the side of the lower, the cut end of this portion of intestine being closed as a blind end, or, if possible, end-to-end anastomosis may be done. We are still left with the problem of dealing with the original lesion, usually pyloric stenosis. This should be treated by gastroduodenostomy or Finney's operation, whichever may be more convenient. If the original lesion was a duodenal ulcer, and there is no stenosis, it is better to excise the ulcer and allow the food to pass the natural way. In some cases the local conditions may render gastroduodenostomy or Finney's operation very difficult. Should this be so, it is probably better to make a new anterior gastro-enterostomy, using catgut only, than to trust to a new posterior gastro-enterostomy of the Y type. In all cases care in diet should be insisted on for a prolonged period, and any symptoms of hyperacidity should be treated by rest, careful dieting, and alkalies.

LIST OF REPORTED CASES.

In the following list, all of the cases, with the exception of those marked with an asterisk (*), have been traced to the original references. The exceptions are those in which I was unable to obtain the original publications. They are, however, published in detail in several previous compilations of cases.

A.—Where the Ulcer has perforated into the Peritoneal Cavity.

1 Braun, *Verhand. d. deutsch. Gesellsch. f. Chir.*, 1899, 94.
2 Hahn, *Ibid.*, 74.
3 Korte, *Ibid.*, 1900, 137.
4 Steinthal, *Ibid.*, 139.
5, 6 Goepel, *Ibid.*, 1902, 108.
7 Goepel, see Tiegel, *Mitteil. a. d. Grenzgeb. d. Med. u. Chir.*, 1904, xiii, 914.
8 Mickulicz, *Ibid.*, 897.
9 Edington, *Glasgow Med. Jour.*, 1907, June, 463.
10 Hall, see Paterson, *Ann. Surg.*, 1909, l, 379.
11 Rushton Parker, see Paterson, *loc. cit.*
*12 Hamann, *Cleveland Med. Jour.*, 1907, May, 183.
13, 14 Battle, *Lancet*, 1906, xi, 274 and 1246.
15 Graser, *Verhand. d. deutsch. Gesellsch. f. Chir.*, 1906, i, 95.

16 HYBRINETTE, see EINAR KEY, *Nord. med. Archiv.*, 1907, xl, Afd. i.
17 LENNANDER, see EINAR KEY, *loc. cit.*
*18 CACKOVIC, *Liecnicki Viestnik*, 1903, vii.
19 DELALOYE, *Deut. Zeit. f. Chir.*, 1906, 518.
20 BRENTANO, *Centralbl. f. Chir.*, 1903, vii, 203.
21, 22 EISELSBERG, *Ibid.*, 1910, 1532.
23 PETRÉN (Bärrhjelm), *Beitrag. z. klin. Chir.*, 1911, lxxvi, 305.
24 PETRÉN (Euren), *Ibid.*
25 JENSEN, see ZULEGER, *Zur Kasuistik des Ulc. pept. Jejuni nach Gastro-enterostomie*, Dissert., Leipzig, 1909.
26 DUDGEON and SARGENT, after CONNELL, *Surg. Gyn. and Obst.*, 1908, No. 1.
27 MAYLARD, *Lancet*, 1910, Feb., 497.
28 HITZROT, *Ann. Surg.*, 1911, i, 571.
29 MARQUIS (Hartmann), *Bull. et Mém. de la Soc. de Chir.*, 1913, Dec. 2, 1517.
30 ROWLANDS, *Guy's Hosp. Gaz.*, 1913, April, 149.
31 NORMAN POINT, see MOYNIHAN, *Med. Rec.* i, 11.
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SOME PHENOMENA OF SURGICAL SHOCK.

By A. RENDLE SHORT, Bristol.

The writer was privileged during the summer and autumn of 1917 to take a part in some investigations on surgical shock and allied conditions at a group of casualty clearing stations in France, and the substance of the present communication is composed of data then obtained. It is very difficult to give proper credit to all to whom credit is due in such a report, because so many of one's colleagues have contributed in a greater or lesser degree, but I have tried to indicate some at least of those whose interest was most active. The opportunity to carry out the investigation was provided by Colonel H. M. W. Gray, to whose kindness and co-operation we were continually indebted.

What is Surgical Shock?—Many patients who arrive at a casualty clearing station severely wounded are, to use the simplest of all descriptions, 'very bad,' and some would use the term 'shock' to indicate this condition of depressed vitality whatever its cause. It seems more useful in practice, and more in accordance with the traditional nomenclature of surgery, to reserve the term for depressed vitality due to traumatism, not including concussion or hæmorrhage. We have therefore to exclude the following factors making for depressed vitality or 'bad'-ness, before concluding that surgical shock is present :—

1. *Considerable Loss of Blood.*—Loss up to a pint does not by itself harm a healthy man, as all of us well know who have been in the habit of taking blood from donors for transfusion.

2. *Concussion*—of brain, spinal cord, or thorax.

3. *Toxæmia from Intestinal Paralysis.*—I am convinced that much which passes for delayed or secondary shock is due to this cause.

4. *Syncope from Mental Effects*, such as sudden pain or emotion. This is a very transient phenomenon.

5. *Toxæmia from Acute Streptococcal Infection or Incipient Gas Gangrene.*—This, again, is a very potent factor, often confused with shock, and accounting for the great majority of cases of 'delayed shock.' It may come on within twenty-four or forty-eight hours of wounding, or, rarely, in eight hours.

It may be doubted at first, when all these deductions have been made, whether any such condition as surgical shock remains to be considered. Admittedly, in war surgery, several factors are usually at work. But there is a residuum. Part of the 'bad'-ness is due to the damaging of tissues. This is shock. It is seen in its purest form in such instances as the following : Gunshot wound of the abdomen, with bad pulse and patient very ill, wound under twenty-four hours (after that period toxæmia takes the larger share in killing the patient) ; crushed chest ; death from amputation at the hip-joint. Big multiple injuries, such as gunshot wounds of both femurs, introduce a lot of shock, with some syncope at first, hæmorrhage later, and toxæmia from infection after a day or two. In ordinary, a patient with a big smash is much worse than one who has lost the same amount of blood from a small clean wound involving an artery, even before toxæmia comes in to complicate the picture.

Phenomena of Surgical Shock.—The well-known signs, such as pallor, loss of muscular power and tone, some blunting of the mind, quick weak pulse, fall of blood-pressure, subnormal temperature, reduced urine, etc., need merely be mentioned. We frequently tested the knee-jerks. They are usually normal ; in deep shock they may be lost.

It is probable that shock may be present before the blood-pressure falls, though it is difficult to recognize it, except that the patient 'looks bad.' This is important, because

we all know how frequently a man is sent off the operating table with a good pulse, but already with his life in grave danger, and a few hours later he suddenly becomes ill and dies.

On the other hand, a fall of blood-pressure does not necessarily prove shock. Turning a patient with gunshot wound of the abdomen after the laparotomy, to excise a wound of the back, may cause a fall of blood-pressure ; but this is quite probably due to syncope, and the patient may quickly recover.

In a small number of instances Captain C. E. Dukes or the writer took readings of diastolic as well as systolic pressure in cases of severe injury with or without signs of shock ; but the double reading did not teach us more than the systolic only.

Metabolism in Shock.—It has been abundantly proved by American workers, using Van Slyke's apparatus, that the alkali reserve of the blood is reduced in shock. There is, in other words, a condition of acidosis (although the terms are not exactly synonymous). Captain C. E. Dukes and I made an investigation of this phenomenon by estimating the ammonia nitrogen in the urine, and found in six cases a constant rise ranging from 13 to 23 per cent (normal is 3 per cent) when shock was present. In two patients who seemed bad, but had normal blood-pressures, the ammonia nitrogen was also normal. It is well known, of course, that the ammonia nitrogen excretion is a simple indirect measure of the H-ion concentration of the blood. In one case, as shock deepened, the acidosis rose from 14·6 to 23 per cent in sixteen hours.

What is the nature of the excreted acid ? It is not β-oxybutyric or diacetic acid ; we never obtained red coloration with ferric chloride even after oxidizing with hydrogen peroxide (to oxidize β-oxybutyric to diacetic acid). It is not lactic acid ; it is true that the urine both of shocked and normal persons may give a yellow colour with Uffelmann's reagent (due to phosphates) ; but when the urine of a shocked patient is evaporated to dryness and the residue extracted with ether, the evaporated ether extract gives none of the reactions of lactic acid. It is probable that the excess of ammonia is carried out by amino-acids. This suggestion was first made to me by Sergeant Howard, of the —th Mobile Laboratory.

Whether the acidosis of shock is cause or effect of the exhaustion symptoms is another and more difficult question. We were in the habit of giving the cases alkaline drinks (citrates are preferable to carbonates, as they do not interfere with the gastric hydrochloric acid). General opinion seems to be that alkaline transfusion is no better in the treatment of shock than normal saline, and therefore it is probable that the acidosis is an accessory, not an essential, factor in the production of the exhaustion symptoms, especially as it follows and does not precede the fall in blood-pressure.

The Suprarenals in Shock.—For my Hunterian Lecture in 1914 I had measured the adrenalin content of suprarenals obtained by autopsy from persons dying of shock and of various other conditions, by determining the dilution necessary to induce contraction in a spiral strip of rabbit's aorta. I could not demonstrate that the adrenalin content of the gland was at all reduced. I repeated the observation on two cases dying of wound shock, and with the same result.

Toxicity of the Blood.—Captain Lindsay performed for me the following experiment : Ten c.c. of blood were taken from the heart blood of a man suffering from severe shock due to gunshot wounds of the abdomen, chest, both legs, and back (no visceral injury, but retroperitoneal hæmatoma), who died thirty-six hours after being wounded, the autopsy taking place within a few hours of death. This heart blood was injected into the ear vein of a rabbit. The rabbit was kept for several weeks, and exhibited no symptoms, except perhaps a transient drowsiness. Ten c.c. is a large dose for a rabbit, and this observation would seem to show that the blood in shock is not always toxic. The experiment was only done on one occasion.

It may be remembered that Professor Crile demonstrated in two dogs with the circulation artificially crossed that the signs of shock were only produced in the dog subjected to traumatism. Roger has shown that the blood of a shocked rabbit is not toxic to another rabbit.

The Blood-vessels in Shock.—The ancient controversy as to whether the arteries are dilated or contracted in surgical shock may now be taken as definitely settled—they are contracted. Indeed, there was never any evidence to the contrary. Dilatation of the arteries was a supposition following upon the theory that the pathology of shock was an exhaustion of the vasomotor centre.

The superficial veins are contracted, and often in a state of active spasm. On quite a number of occasions this has been very forcibly impressed upon us by the extreme difficulty in getting blood to enter the median basilic or median cephalic vein during blood transfusion. There was no doubt that the cannula was correctly placed. In some cases the blood could be seen distending the vein for an inch or two up. We have several times been compelled to leave the arm veins and give the blood by the internal saphenous in the groin, and even that has been found in a state of extreme contraction. It is true that all these cases had bled severely; but I believe some contraction of the arm veins is also present, in a less degree, in pure shock (e.g., in amputation at the hip-joint for tubercle in a wasted boy).

It has been theorized for years that the abdominal vessels are dilated in shock; but in acute abdominal catastrophes and early cases of gunshot wound of the abdomen before the advent of peritonitis, I have never seen any noteworthy vasodilatation either of veins or arteries. It has also been theorized that the liver is greatly engorged; but this is not found either at operation or post mortem.

The condition of the capillaries opens up some new and very interesting problems. Dr. Dale has shown that in histamine-poisoning in cats, the symptoms closely resemble those of surgical shock; there is a fall of blood-pressure, yet the heart is working well, and the arteries are contracted. The crucial problem in shock has always been how to explain a fall in blood-pressure with a normal heart, contracted arteries, and unexhausted suprarenal glands. In poisoning by histamine and certain other substances (acetyl-choline and *minute* doses of adrenalin), one has a similar problem. Dale advances what seems to be satisfactory evidence that in poisoning by these drugs the capillaries are dilated though the arteries are contracted. He also points out that a few hours or days after section of the sciatic nerve in a cat, the pads of the foot on the operated side are paler (= capillary contraction), though that paw is *warmer* than the other, not only to the touch but also to exact measurement; for if both paws are immersed in water in test-tubes, the water on the side of the denervated paw is warmed up more quickly than the other (= arterial dilatation with capillary contraction on the operated side). There is, of course, no theoretical difficulty in imagining that the endothelial cells of the capillaries may be capable of expansion and contraction like the pigment cells in a frog's skin. Moreover, what Dale interprets as capillaries might mean the smallest arterioles with a muscular coat. That a drug should constrict one part of an artery and not another cannot be excluded as improbable, in view of the known variation in action of adrenalin on the pulmonary artery in its different parts (Douglas Cow).

Now, is the fall of blood-pressure in shock, associated as it is with an active heart, contracted arteries and veins, and unexhausted suprarenals, due to capillary dilatation? Cannon has published figures indicating that in shocked wounded soldiers there is a higher red blood corpuscle count in the capillaries than in the veins. Captain Lindsay, Captain Dukes, and others, made a few such counts when working with me, and only found this disparity in one case out of five. [A Thoma-Zeiss hæmocytometer was used. Some of the hæmocytometers at the front were very inaccurate.] If the capillaries in shock are dilated, one would expect the lips and conjunctivæ to be flushed instead of pale. It is to the lips that we look for the capillary flush in aortic regurgitation. It is quite possible, however, that the relaxation of muscular tone to which, in my Hunterian Lecture, I attributed considerable importance in the causation of the low blood-pressure, may allow of dilatation of the intramuscular capillaries.

The Blood Volume in Surgical Shock.—War surgery does not offer many good opportunities for studies of the total blood volume by estimation of the specific

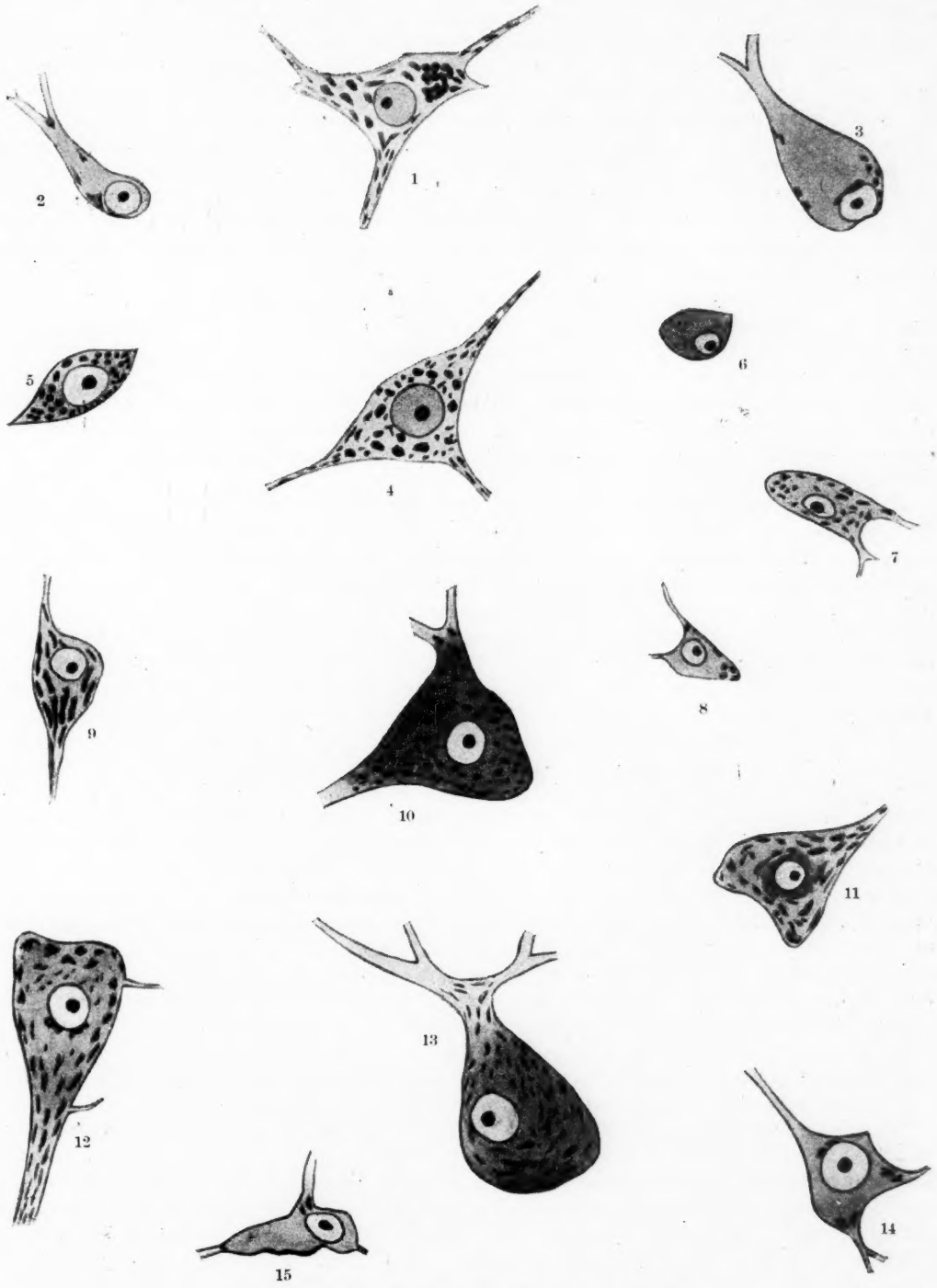

FIG. 338.—NERVE CELLS FROM CASES OF FATAL SHOCK.

1, Nucleus of twelfth nerve: upper medulla. 2, Small-celled dorsal nucleus of vagus: upper medulla. 3, Nucleus ambiguus: upper medulla. 4, Anterior horn of spinal cord. 5, Clarke's column. 6, Nucleus gracilis. 7, Lenticular nucleus. 8, Inferior olive. 9, Substantia nigra. 10, Nucleus of third nerve. 11, Red nucleus. 12, Betz cell. 13, Superior vermis of cerebellum. 14, Postcentral cortex. 15, Optic thalamus.

gravity, red-cell counts, or direct measurement by the vital-red method, because so many of the cases are complicated by unmeasured hæmorrhage. In pre-war civil surgery I found no alteration of the specific gravity in eight cases, but a marked concentration in two patients with severe burns. Observations by the vital-red method on cases of pure shock are urgently needed.

The Central Nervous System in Patients Dead of Shock.—I have had the opportunity of cutting sections of the various parts of the brain and spinal cord of three patients dead of shock. Particulars are given in the appended protocol. It will be observed that in one of them at any rate (the second), the loss of blood was measurable, because there was no external bleeding, and it was not more than one can take with impunity from a donor for blood transfusion; so that it does not seem that cerebral anæmia will explain the changes found.

In the main, the findings may be summarized as follows: The nerve cells of the sympathetic ganglia and of the spinal cord show no changes. The sensory nuclei of the brain (gracile and cuneate nuclei, optic thalamus) show profound loss of Nissl granules, indicative of cell exhaustion. The motor nuclei (Betz cells of precentral cortex, motor nuclei of medulla and pons, lenticular nucleus) are normal. The Purkinje cells of the cerebellum, as Professor Crile has pointed out in all his writings, show considerable loss of Nissl granules in most cases. In one case the vagus nuclei had lost all its granules.

No one is more conscious than I am that research by this laborious method needs to be extended to many more cases and controls before these generalizations can be safely accepted; but they appear to me to suggest that the violent nociceptive (painful, or, in an anæsthetized patient, potentially painful) impulses passing up to the brain wear out first the sensory nerve nuclei and then the great vital centres.

It is well known that similar changes can be induced in nerve cells by exhaustion, and that the normal appearance of the cells can be restored by sleep. Here we find the rationale for the sleep treatment of shock on which Professor Crile has rightly laid such stress.

PREVENTION AND TREATMENT OF SHOCK.

I do not propose to enter very fully into this subject, but to give a personal impression of measures in general use. In practice—in war surgery—it is nearly always the shock-hæmorrhage syndrome that one has to treat.

Fluids.—There is no doubt as to the value, slight but definite, of giving fluids. We used a hot alkaline drink (potassium citrate) to counteract acidosis. Tea or coffee is good. Saline per rectum and saline subcutaneously are often helpful up to a certain point; but when it comes, as it often does, to a question whether to get the patient comfortable and asleep under morphia, or to worry him with rectal or subcutaneous saline, I prefer the sleep and morphia treatment as more merciful and, I think, more efficacious.

Warmth is of great value in the prevention, and some value in the cure, of shock. Many excellent methods of applying it are now well known.

Sleep is also of considerable value. To secure it one must try to get seclusion, quiet (fill the patient's ears with wool, if necessary), warmth, darkness, and, usually, morphia in adequate doses. I do not believe that any quantity of morphia will do a patient any harm if it does not first give him ease and quiet—with the very important proviso that it must be given in divided doses at hourly intervals ($\frac{1}{4}$-, $\frac{1}{3}$- or even $\frac{1}{2}$-grain doses in the worst cases), and that the patient's circumstances must be such that he really has a chance to sleep if the morphia inclines him to. It is not necessary, as Professor Crile advised, to repeat the dose every hour until the respirations are reduced to twelve a minute; but I shall never forget a case of gunshot fracture of the femur under the care of Lieutenant-Colonel Dun. I saw the patient at 2 o'clock, after he had had repeated $\frac{1}{4}$-gr. doses since admission in a state of shock at 10.30; although he had received over

2 grains of morphia in four hours, he was awake, free from pain, his pupils were not contracted, and his pulse was better. He did well. At any rate, such a case convinced one that perhaps in this country we had been too timid in our use of this most valuable drug for patients in extreme pain.

Drugs.—Adrenalin is dangerous. Strychnine is certainly useless, and possibly dangerous, as Professor Crile and Mr. Lockhart Mummery long ago pointed out. Alcohol may give a little Dutch courage to patients with syncope who like it, but in shock it does nothing but harm, especially after ether or chloroform has been given, for in that case it has not even the brief stimulating effect that may precede the longer depression. Pituitary extract is given on a theory that shock is due to arterial dilatation; the theory is erroneous, and the drug is useless unless there is an element of intestinal paralysis in the case; for that condition it is our best remedy. Camphor is well spoken of by some; I do not use it, and cannot speak from experience. Digitalin is, I think, useful both on theoretical grounds and as a matter of experience. One is almost compelled to give some hypodermic remedy, to pacify patients, friends, and nurses. It does not appear to be universally known how common it is for patients' pulses to fail during the later stages of an operation, and then to improve greatly, quite apart from any drug treatment, during the stitching up and application of dressings. It is this phenomenon which has given a fictitious reputation to strychnine, pituitary, etc., in the treatment of shock during an operation.

Transfusion.—Saline given intravenously has a definite, though very small, value; it frequently tides the patient over a brief period, such as an operation; but in a few hours its value is all gone, and in the great majority of cases death is not averted, only postponed. I am told by colleagues who have used alkaline transfusion and gum, that this is no better than saline.

With regard to gum transfusion, advocated by Professor Bayliss, it is usually harmless, and if given *immediately* after a hæmorrhage it may be life-saving in animals; but it seems very doubtful, both experimentally and clinically, whether it is any use to give it several hours after. Moreover, one has a prejudice against leaving such an extraneous substance as gum in the circulation.

Blood Transfusion.—In my opinion—based on about 40 cases which were given blood, usually from 15 to 20 ounces, by my colleagues or myself—blood transfusion is far more effectual and lasting as a remedy for the shock-hæmorrhage syndrome than any of the other substances mentioned. At first we used direct transfusion from the radial artery of donor to the median basilic vein of patient. In two cases it did well; but in two others I am sure that very little blood passed. It is impossible to know how much one gives, and the veno-spasm of the recipient must often prevent his receiving a single drop.

The method we afterwards used was that described by Captain Robertson, and originally devised for us (with some minor differences) by Captain Lindsay. It was worked out first on rabbits. *Group IV* donors were always used after Captain Robertson had shown us how to test them out.

Whether blood transfusion is of the same value for pure shock is a more difficult question; but the results were quite encouraging in some cases in which the shock element was larger than the hæmorrhage.

The observations and suggestions embodied in this paper are fragmentary, and need further extension; but they are placed on record to give interested workers on this great and important subject some lines of approach which they may care to follow up. In civil practice cases of severe shock are so infrequent that future investigation may be difficult.

I have not attempted in this communication to deal with the voluminous recent literature, but have reserved that for an article in the forthcoming volume of the MEDICAL ANNUAL.

PROTOCOL OF OBSERVATIONS ON THE HISTOLOGY OF THE CENTRAL NERVOUS SYSTEM IN PATIENTS DEAD OF SHOCK.

Case 1.—Man. Fell from ladder. Fractured pelvis, fractured humerus, retroperitoneal hæmatoma. There was no external hæmorrhage. Died 2½ hours after injury.

Case 2.—Pte. C. Run over by a lorry. Admitted suffering from crushed chest, in extreme pain. No external wound. Died 24 hours after injury.

Autopsy showed pulping of the whole of the left lung, fracture of seventh and eighth ribs, and 1½ pints of blood in the pleura.

Case 3.—Pte. S. Gunshot wound of back, with fractured spine, wound entering the abdomen; also multiple wounds of legs. Had lost much blood. Died 4 hours after wounding.

Case 4 (Control case).—Pte. G. Injury of head, not penetrating skull. Died about 48 hours after injury, without recovering consciousness.

CHANGES IN NERVE CELLS.

NUCLEUS	CASE 1	CASE 2	CASE 3	CASE 4
Posterior root ganglion (left seventh dorsal)	—	Normal	—	—
Spinal cord, anterior horn	—	Normal	Normal	—
„ „ posterior horn	—	Normal	Normal	—
„ „ lateral horn	—	Normal	Normal	—
Precentral cortex (Betz)	—	Normal	Normal	Granules reduced
„ „ (other cells)	—	Granules deficient	Normal	Granules almost absent
Postcentral cortex ..	—	Granules only well-marked in half the cells	Granules deficient, some cells empty	—
Optic thalamus	—	All cells almost devoid of granules	Almost no granules	Almost no granules
Cerebellum (Purkinje) ..	Normal	Deficient in granules	Granules very deficient	Granules very deficient
Medulla gracile nucleus	No granules	No granules	Almost no granules	Some deficient, some normal
„ cuneate „ ..	No granules	No granules	Almost no granules	Some deficient, some normal
„ inferior olive ..	Mostly normal	Granules deficient	Granules deficient	Almost no granules
„ XIIth nucleus	Normal	Normal	Normal	Normal
„ Deiter's „ ..	Granules reduced	Normal	Rather reduced in granules	—
„ arcuate „ ..	—	Normal	—	—
„ nucleus lateralis	—	Normal	—	Granules deficient
„ „ ambiguus	—	No granules	Almost no granules	Normal
Pons, VIth nucleus ..	Normal	Normal	—	—
„ Deiter's „ ..	—	Normal	—	—
„ superior olive ..	—	Normal	—	—
„ nucleus pontis ..	—	Granules about half normal	—	—
Substantia nigra ..	—	—	Normal	—
IIIrd nucleus	—	—	Normal	—
Red „	—	—	Normal	—
Lenticular nucleus ..	—	—	Normal	—

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A NEW SYSTEM OF LOCALIZATION AND EXTRACTION OF FOREIGN BODIES IN THE BRAIN: A PRELIMINARY NOTE.

By Captain J. NEWBERY FERGUSSON, R.A.M.C. (T.C.)

About two years ago, as officer in charge of the *x*-ray department of a general hospital at a base, I had occasion to examine a series of gunshot wounds of the head. A retained missile was localized in a considerable number of the cases examined, and in some of these operation was performed for extraction. I was present at most of the operations, and gradually came to realize that the methods of extraction were far from ideal. It seemed almost waste of time to determine the exact situation of the foreign body in relation to surface landmarks, when the localization was applied, at operation, merely by visualizing the measurements. The use of a finger, too, as an exploring instrument, did nothing to dispel the idea that our operative methods were imperfect. It is true that in most cases the missile was extracted, but often at the sacrifice of a considerable amount of brain tissue.

Convinced of the necessity for improved technique, I devoted much thought to devising a system of extraction which would reduce the operative trauma. The idea of enabling the surgeon to take full advantage of an accurate *x*-ray localization, by substituting mechanical control of the extracting instrument for visualization and digital exploration, particularly appealed to me, and the following notes outline its ultimate development.

The difficulties and dangers of the ordinary methods of extraction can be summarized for the purposes of this paper in a few lines. In the absence of any instrumental guide, it is difficult, and often impossible, to make use of the *x*-ray localization with any degree of precision. The missile can seldom be seen, and exploration of the brain cannot be carried out with the same impunity as in many other parts of the body. Though the foreign body may be felt with a probe, it is nevertheless difficult to grasp, and considerable damage may be done before it is extracted. The practice of introducing the finger along the track makes the extraction easier; but this technique is dangerous, especially when the missile is deeply situated, because it causes mechanical trauma, and aids the spread of sepsis, partly by physical dissemination of organisms, but perhaps to a greater extent by opening up lymph spaces and thus generalizing a local infection. If this damage could be reduced to the minimum, it would seem just as reasonable a procedure to extract a foreign body from the brain as from any other part.

In devising the method presently to be described, the chief considerations I had in view were that it should enable the operator to apply the information conveyed by *x*-ray localization with the utmost precision, and should admit of extraction being performed with the minimum of avoidable damage, either along the track of entry or through a fresh wound in any more convenient situation. The accompanying photographs illustrate the apparatus which I have had made for this purpose.

It will facilitate comprehension of the underlying idea if I compare it with the artillery system of 'indirect fire,' to which it bears in some respects a close resemblance. Just as a gunner can hit a concealed target when its direction and range from the firing point have been ascertained, so by the use of this apparatus can the surgeon extract a foreign body from the brain after its direction and distance from the operation wound have been indirectly determined. The gun is represented in the apparatus by a tubular guide, held rigidly close to the wound, and aimed through it at the concealed foreign body in a manner to be described. A long, slender, cylindrical-stemmed forceps, capable of

sliding through the tubular guide without resistance, takes the place of the shell; and the distance at which it will be able to grasp the foreign body, when pushed into the brain along the guide, represents the range. The gunner 'lays' his gun by bringing his dial-sight to bear on an aiming-post, or some conspicuous object in the landscape; the surgeon also makes use of an 'aiming-post,' as will be explained later. Certain parts of the apparatus which enable the tubular forceps-guide to be manœuvred into position and

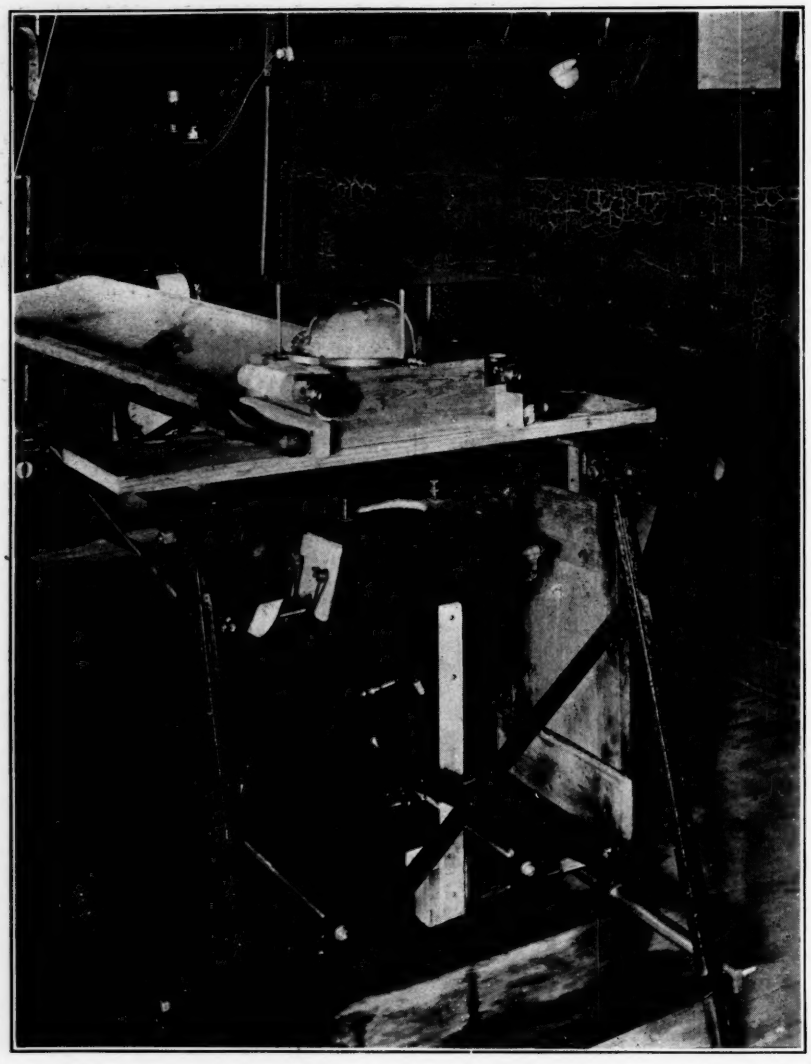

FIG. 339.—Method of obtaining double-exposure negative. The patient is so placed that the median plane of the head, with attached apparatus, lies horizontally, the weight of the head being borne by a head-rest consisting of a three-sided box across which hangs a canvas sling controlled at its ends by rollers. The head is lowered, after attachment of the apparatus, until the latter just touches the upper edge of the head-rest, in which position it is perfectly immobile. The *x*-ray plate lies above on three supports attached perpendicularly to the semicircle; the *x*-ray tube is below.

maintained there, may be compared with the mounting of the gun; while the steel semi-circle partly surrounding the skull, to which it is rigidly fastened, serves to support the whole apparatus, and may be said to correspond to the concrete platform on which the gun stands. The essential feature of the apparatus is that it enables the operator to direct a forceps of special design through the brain with such precision that the missile

is grasped and extracted without the use of any other instrument, or of a finger in the wound.

The apparatus consists essentially of a steel semicircle which can be fixed rigidly to

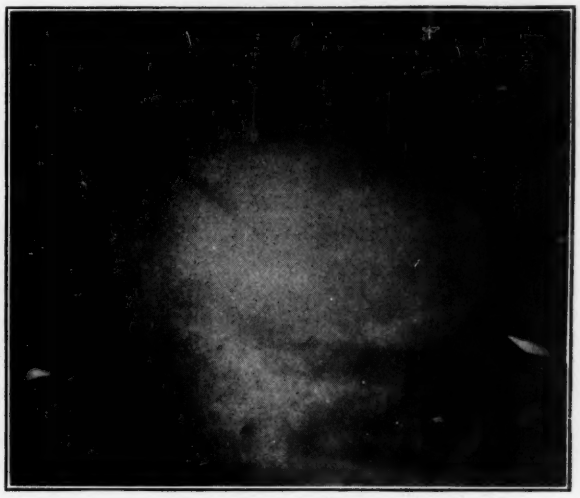

FIG. 340.—Double-exposure negative. The points of the plate-supports, having been in virtual contact with the plate, cast but one shadow each; the missile casts a double shadow. The skull appears as a blurred shadow, due to the overlapping of the two images; this is the explanation, also, of its apparent shortness. This negative belongs to *Case* 2.

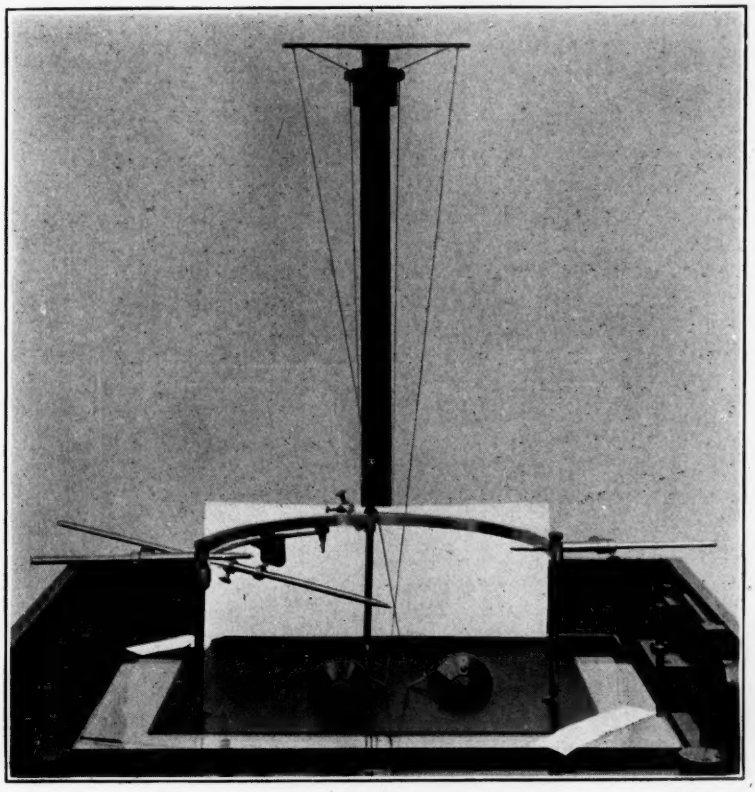

FIG. 341.—Localization by Mackenzie Davidson's cross-thread localizer. The apparatus stands on the negative in an inverted position, with the points of the plate-supports in correct register with their shadows. The points of suspension of the threads correspond with the positions of the focal point of the tube during the two exposures. The needles holding the lower ends of the threads rest on the shadows of the foreign body. The indicating probe has been set to mark the point of crossing of the threads, i.e., the position of the foreign body in relation to the apparatus.

the head in the sagittal plane by means of three pointed rods which fit into recesses drilled to receive them in the outer table of the skull. The provision of registering collars on the rods makes it possible to remove the apparatus from the head and restore it to

position without any error. Special instruments are used to make the holes in the outer table of the skull, the operation being effected through a 5-mm. incision. The incising and boring instruments are used through the sleeves which hold the fixing rods, thus ensuring that the holes shall be drilled in precisely the right places. It is then quite easy to 'feel' the points of the fixing rods into the holes.

The head with attached apparatus is photographed laterally by the double exposure method (*Fig.* 339), the plate being supported on three uprights attached perpendicularly to the semicircle; from the negative (*Fig.* 340) thus obtained the position of the missile

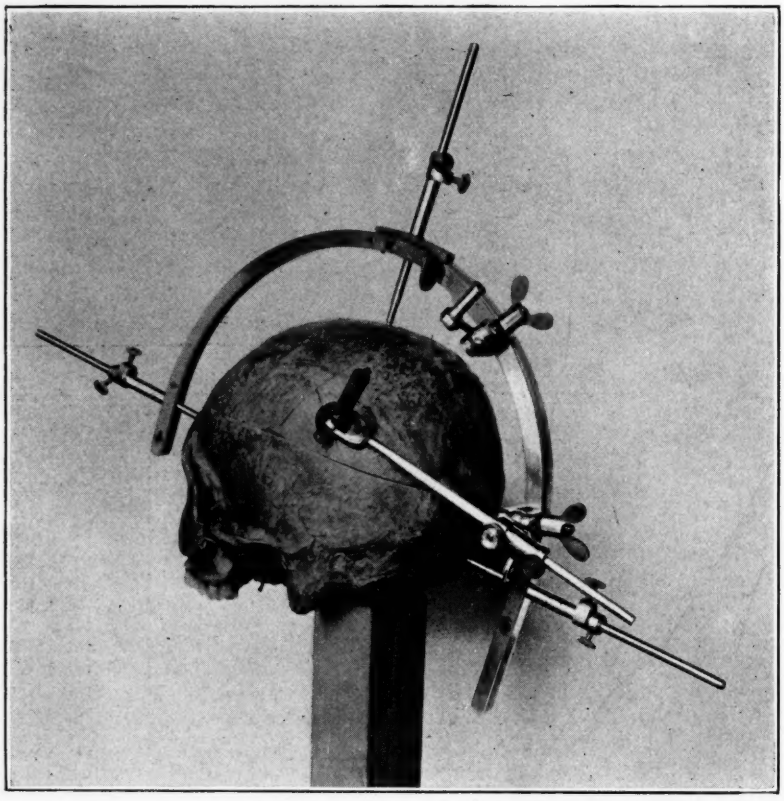

FIG. 342.—Apparatus attached to head at time of operation. The tubular forceps-guide has been placed opposite the wound through which extraction is to be performed. The placing of the guide in any desired position is rendered possible by means of: (1) A ball-and-socket joint controlled by a butterfly nut, supporting (2) A sleeve furnished with two thumb-screws, one of which can suppress longitudinal movement, and the other revolution of the stem which passes through it; and (3) A joint between the tubular part of the guide and the stem (which might be described as a 'one-pronged fork'); this joint can be rendered rigid by tightening the little hexagon nut with a clock-key spanner. When the guide has been placed in the position desired, the butterfly nut of the ball-and-socket joint, and the screw on the sleeve controlling longitudinal movement of the stem, are tightened. The other screw and the hexagon nut are left loose. The result is that the guide-tube is fixed in position, but its direction is still capable of being modified to enable it to aim at the foreign body.

The joints are provided with spring washers. When tightly screwed up they are perfectly rigid; but when unscrewed a little they can be moved with sufficient resistance to prevent the component parts from moving by their mere weight.

relative to the apparatus is determined by the cross-thread method of localizing (*Fig.* 341). This position is marked by the point of a probe fixed to the apparatus in such a way that it can be removed and restored accurately to position whenever necessary.

When the operator is ready to perform extraction, the apparatus, sterilized in any convenient way, is fixed to the head exactly as before, so that it comes to occupy the same relation to the foreign body as at the time of *x*-ray examination (*Fig.* 342). The tubular forceps-guide already alluded to is now placed in position over the wound through which it is proposed to extract the foreign body. On reference to *Figs.* 342, 343, 344, it

will be seen that the forceps-guide is attached to the semicircle by a device which enables it to be placed in any position, and to be fixed rigidly when desired. The end of the tube next the wound is supported in a kind of universal joint, about which the other end is free to move ; but once manipulated into correct position, it can be fixed there securely. The next step is to make it aim accurately in the direction of the missile, and to determine the depth at which the forceps will be able to grasp the objeet. To enable this to be done,

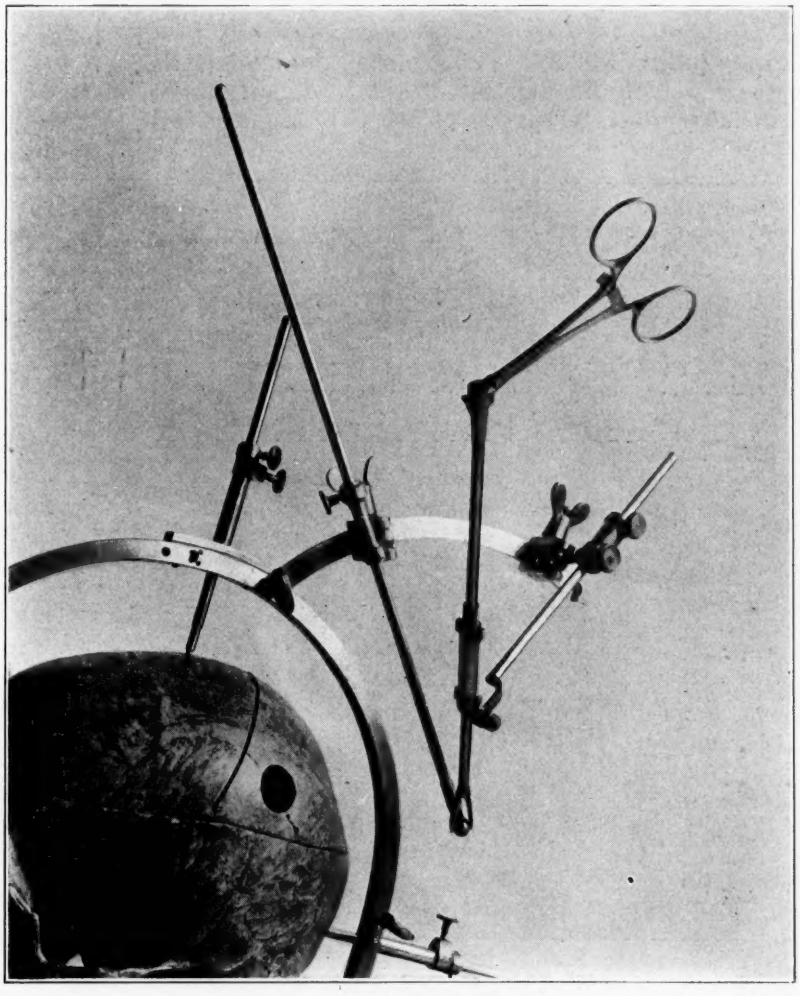

FIG. 343.—The sector carrying probe-guide and forceps-guide has been swung aside. The probe having been placed in position, the forceps, introduced through its guide, has been manipulated to seize the point of the probe. This operation is rendered easier if the point of the probe is covered with a small ball, as shown in the photograph. The forceps is described in the text. Observe the short piece of rubber tube on the stem of the forceps, which has been slid up into contact with the end of the guide-tube.

The probe and forceps must be withdrawn before the sector can be restored to position.

that part of the apparatus which supports the probe-guide and forceps-guide is temporarily swung out of position (*Fig.* 343) by releasing a couple of thumb-screws, this procedure being more convenient than the alternative of removing the whole apparatus from the head. The probe having been placed in position in its guide, the tubular forceps-guide is made to aim correctly by inserting the forceps and manipulating it until it grasps the point of the probe, which, it will be understood, indicates the position of the missile. The forceps-guide is now fixed rigidly in its position, and a short piece of rubber tubing on the stem of

the forceps is slid up into contact with the free end of the guide, to register the depth at which the forceps will be able to grasp the missile. After withdrawing forceps and probe, the part of the apparatus supporting their guides is replaced in position. The forceps-guide comes thus once more opposite the wound, but it now aims correctly at the foreign body (*Fig.* 344).

The forceps, lubricated with a little sterile oil, is introduced through the guide, and gently pushed into the brain until within a short distance of the depth at which the blades can grasp the missile, as indicated by the approach of the short piece of india-rubber tube on the stem to the free end of the forceps-guide. If there is any marked difference in the length of the principal diameters of the missile, the forceps must be given the correct orientation to grasp it by its smallest diameter. It is assumed that the radiographer has formed a fairly accurate opinion of the size, shape, and lie of the missile from

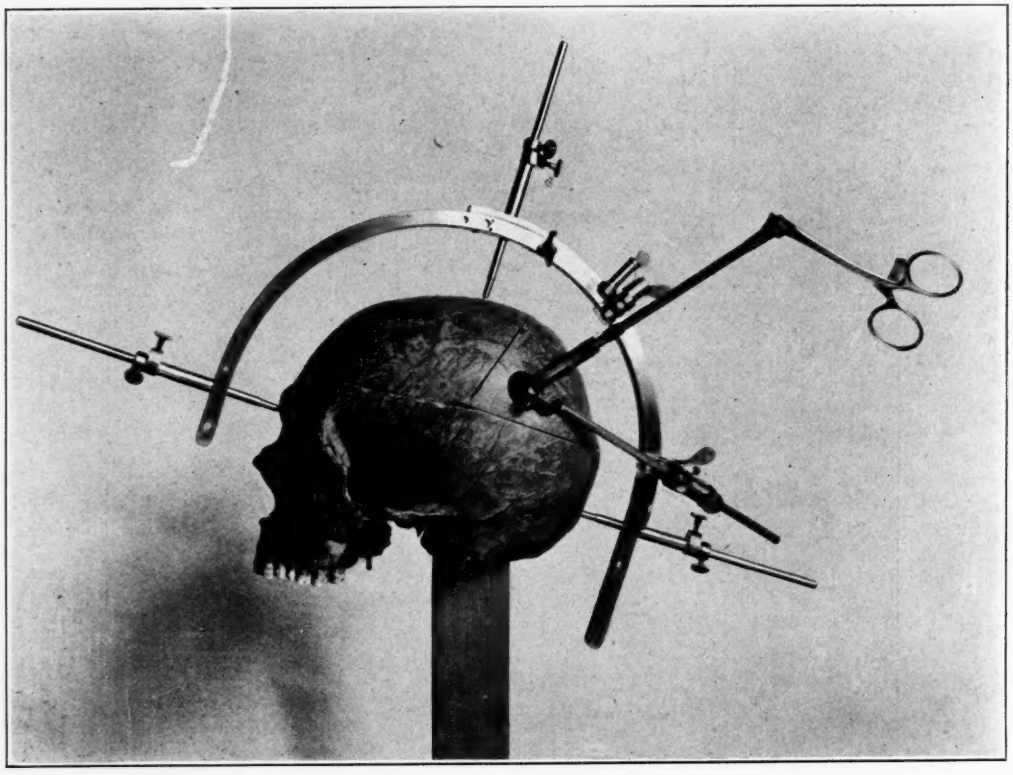

FIG. 344.—Sector again in position. The forceps-guide now has correct direction, i.e., it aims at the foreign body. The forceps has been introduced closed until within a short distance of the foreign body, as indicated by the approach of the piece of rubber tubing on its stem to the end of the guide. It is at this stage that the jaws should be opened before the final advancement to grasp the foreign body. Observe the graduated scale near the finger-rings of the forceps which indicates the degree of separation of the jaws.

preliminary examination, preferably from two plates taken in planes at a right angle. The estimated size of the missile will determine how far the forceps should be introduced before opening the jaws, and also the degree of opening necessary to enable the missile to be grasped. The jaws having been opened to the extent required, as indicated by a small scale near the loops of the handles, the forceps is introduced the remainder of the distance, i.e., until the piece of rubber tube on the stem comes into contact with the free end of the guide. The jaws should now embrace the foreign body, and the sensation on closing the handles should enable the operator to feel that it has been grasped. On withdrawing the forceps with the missile in its grasp, progress will be arrested as soon

as the jaws—now open to an extent depending on the size of the missile—come in contact with the guide. To meet this difficulty, the guide is made in two sections, one of which can easily be slid off, enabling extraction to be completed without altering the position of the guide.

As the fixed section of the guide-tube remains in position, it can be used to facilitate the introduction of a drain, if the operator so desires. As an example, a glove finger or a small roll of 'rubber dam' is seized in the forceps by means of which extraction has just been performed, and is introduced with perfect accuracy into the cavity recently occupied by the missile, by passing the forceps along the guide to the depth indicated by the rubber collar on the stem. The operation is completed in the usual way, after removing the apparatus.

In this brief sketch it has been necessary to suppress a great deal of technical detail connected with localization; but it may be stated that the special technique of the process renders it accurate within a negligible degree of error. I have also omitted much that might be said on the subject of extraction.

As regards mechanical details of the apparatus, the illustrations, with the explanatory notes accompanying them, must for the present suffice; but an exception must be made in favour of the forceps, which requires special mention. This resembles 'crocodile' forceps in general outline, but differs from them in that both jaws open and close together and equally. The stem is long, slender, and cylindrical, 5 mm. in diameter, about the size of a No. 8 catheter. The jaws are slightly hollowed, and finely serrated. They taper together to a sharp flat end, so that when closed the instrument resembles a long slender screw-driver. Being considerably less in diameter than the average foreign body usually described as 'worth going for,' the forceps possesses obvious advantages over ordinary means of extraction. Its sectional area is only one-sixteenth of that of the average forefinger; it goes straight to its work without any 'hunting about'; and its length is such that, theoretically, it can be used to extract from any depth. It is to be noticed that the depth of the foreign body does not in any way influence the accuracy of the instrument. In one case, for instance, I extracted a small piece of metal along its track of entry from a depth of 3½ in. In cases of late extraction performed through a healing wound, the use of the forceps should reduce the risk of breaking down the adhesions which form between the meninges and neighbouring tissues and tend to limit the spread of sepsis along the surface of the brain. Extraction of foreign bodies giving rise to symptoms long after healing of the original wound, might be performed with much less mechanical trauma than is possible by ordinary means. In short, when (as in most cases) the diameter of the foreign body exceeds that of the forceps, the purely mechanical damage done in the course of extraction will usually be limited to that necessarily caused by the missile itself.

To illustrate the application of the method, I append short descriptions of two cases, one of which is chosen because it shows under what circumstances failure is apt to occur.

Case 1.—Pte. S. H., Royal Irish Rifles, age 23, wounded Aug. 16, 1917, was admitted to a base hospital on Aug. 21, under the care of Lieut.-Col. T. P. Dunhill, A.A.M.C. The entrance wound was on the right side, at the level of the lobe of the ear, and the track passed inwards and upwards, through the ascending ramus of the jaw and the base of the skull, and the missile, having crossed the mid-line, finally came to rest in the posterior part of the left frontal lobe, ½ in. from the superior longitudinal fissure and 1½ in. from the surface.

Abstract of Clinical Notes.—Aug. 21, both eyes closed from very great ecchymosis of lids, and subconjunctival œdema. *Right eye*—some proptosis; cornea clear; iris bright; pupil larger than that of left eye; ocular movements limited; definite optic neuritis; swelling 1·5 D. *Left eye*—normal except for indistinctness of outline of disc, with no definite swelling. Can count fingers with either eye. Diplopia except when looking straight ahead. Babinski great-toe phenomenon present. No other neurological signs. Temperature 98°–99°; pulse 68–58.

Aug. 26.—Optic neuritis more marked. *Right eye*—swelling 1D. *Left eye*—swelling 3D. Temperature 100°; pulse 44.

Col. Dunhill kindly invited my collaboration in this case, and operation was performed on Aug. 27. After localization had been completed in the manner already outlined, Col. Dunhill exposed the dura through a large quadrilateral opening whose centre was about 2 in. above the left external angular process, and the forceps, having been given the proper setting, was introduced through a small crucial incision. This mode of approach was chosen because it was obviously impossible to extract the missile along its track of entry. The attempt to grasp the missile was not successful, but the reason for failure was at once evident when pus and gas bubbles gushed out along the stem of the forceps: an abscess cavity existed in which the missile was free to move. Foreseeing this eventuality, we had given orders that the patient was not to be moved from the position in which he was *x*-rayed until the operation was completed; but as he was carried from the *x*-ray room to the adjoining theatre in the arms of orderlies, there is little doubt but that the foreign body was given an opportunity of moving. The abscess cavity contained about a drachm of pus mixed with gas bubbles, and on exploration the foreign body was detected lying in it, as far as could be judged about $\frac{1}{8}$ in. from the position where it was expected to be found. It was 'vomited out' soon after exploration of the cavity, and proved to be a chip of steel 3 or 4 mm. thick, whose outline was irregularly ovoid, with a major axis of about 12 mm. A glove-finger drain was inserted, and the wound partially closed.

A month after the operation, both wounds (entrance and operation) were completely healed, and there was no pain. The oculist reported that there was no swelling of the discs, and apart from some want of definition of their edges, nothing abnormal to be detected in the fundi; the right eye had receded, but its movements were still limited, and there was diplopia, with upward and downward movements. The patient was evacuated to England about the beginning of December, 1917, but he had been walking about long before that date.

It must be acknowledged that the attempt to extract the foreign body with forceps was a failure; but the operation was successful in every other detail, and illustrates the use of the apparatus in its minor rôle—as an indicator.

Case 2.—Pte. J. B. W., 2nd H.A.C., age 29, wounded Oct. 9, 1917, was admitted to another base hospital two days later. The wound of entry was in the left temporal region. The notes on the case record partial aphasia, right hemiplegia, right knee-jerk absent, extensor response to plantar stimulation on right side, bladder and rectum normal, temperature normal, pulse 84. *X*-ray examination (stereoscopic plates) showed the presence of a small foreign body in the left side of the brain, in the region of the upper end of the Rolandic area, its depth from the surface being estimated at $3\frac{1}{2}$ cm. It had entered the skull through a small punctured fracture $1\frac{1}{4}$ in. posterior to the external angular process, and immediately behind the groove for the anterior division of the middle meningeal artery.

As the patient's condition seemed to be getting worse, operation was performed on Oct. 16. The missile was localized in the manner already described, and as there was a considerable interval between it and its wound of entry, it was judged expedient to extract it through a fresh wound. Accordingly, Major G. de la Cour exposed the dura mater between the left parietal eminence and the sagittal suture, by removing bone of the size of a two-shilling piece. The apparatus having been replaced on the skull, the direction and depth of the missile were determined as previously described. A small incision was made in the dura, and the forceps was advanced through the brain with the proper orientation. The missile was grasped and removed without the slightest difficulty. It was a piece of steel, 10 mm. long by 5 mm. broad. As there was no evidence of sepsis, the wound was closed without drainage. The wound of entry appeared clean, and so received no special treatment.

A day or two after operation, considerable improvement in the general condition was noted, the aphasia was markedly less, and the patient was able to recognize the man in the adjoining bed. His further progress was rapid, and he was evacuated to England ten days after operation.

A letter from England, dated Dec. 27, 1917 (about ten weeks after operation), from which I quote a few lines, records continued progress:—

> I am glad to tell you he is going on splendidly. He has free use of his right leg, and it is just his foot that is not working now. His right arm also is going on well; he can wave it about, and almost shake hands. The fingers have not much use so far, so he is unable to write. He can read, and he never feels any pain in his head.
>
> I notice a difference in him every week, and he is so cheerful. His voice is all right again; at first he used to hesitate rather a lot. Now he says that if he speaks slowly he does not find any words difficult.

The negative reproduced in *Fig.* 340 belongs to this case, and illustrates the only difficulty that occurred in the operation. The incision for the posterior fixing-rod was made a trifle too low, just below instead of just above the external occipital protuberance, and the tough ligamentum nuchæ made it a little difficult to fit the fixing-rod into the hole made to receive it in the outer table of the skull.

The fact that the instrument is designed primarily to perform extraction, and not merely to facilitate it, should serve to distinguish it from the many varieties of indicating instruments already in use. Though they are often of value in other parts of the body, where a good exposure can be obtained and exploration does little harm, such instruments are obviously less suited for use in brain cases.

It is inevitable that any written description must convey the impression to the reader that the use of the apparatus is full of complexities, but five minutes' demonstration with a skull would show that such is not really the case. Provided that the instrument is used with care and exactitude—much of the technique for ensuring which is omitted from this description—there is nothing difficult about it.

With a few minor exceptions the whole of the apparatus has been made to my design by a clever French mechanic.

In conclusion, I have to thank the commanding officers of the hospitals in which the two above-mentioned cases were treated, Colonel J. A. Dick, A.A.M.C., and Lieutenant-Colonel S. G. Butler, D.S.O., R.A.M.C., for kindly allowing me to report them.

A STUDY OF A SERIES OF PERIPHERAL NERVE INJURIES FROM A SURGICAL ASPECT.

By Brevet-Major J. L. JOYCE, R.A.M.C.T.

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5. The Unoperated Cases.
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Conclusions.

INTRODUCTION.

This paper is devoted to the study of the surgical treatment of war-injured nerves. The writer has dwelt mainly on the operative treatment. Not that he minimizes the importance of the pre-operative and post-operative treatment, involving the various resources of physiotherapy and the employment of prosthetic appliances. On the contrary, the importance of each item of such treatment is thought to be of sufficient magnitude to deserve a separate and special study. In the treatment of every case of nerve injury, frequent collaboration and consultation between surgeon, neurologist, masseur, and electrotherapeutist is a *sine qua non* of a successful result.

Before the war nerve injuries were relatively few in number. The surgeon had at his disposal many objective findings from physiological and histological research, but few if any case-histories from which to draw conclusions. Thus, it seems to the writer, has a tendency sprung up to elucidate and confirm the former by the latter. Such a method can only lead to artificial conceptions. Now that such a large amount of clinical material has become available, the opposite method must be adopted. With this end in view, and in the hope that fresh light may be thrown on the operative treatment of injured nerves, the study of the following series of cases has been undertaken.

The illustrations are the work of Private Shaw, R.A.M.C.; the majority of them are finished copies of drawings made by the writer immediately after operation; the remainder are original.

My thanks are due to Captain Johnston, R.A.M.C., for many useful criticisms, and to my commanding officer, Brevet-Colonel W. J. Maurice, R.A.M.C.T., for his permission to make use of the case-histories.

MATERIAL AND RECORDS.

During the period May, 1915, to April, 1918, 150 cases of injured peripheral nerves have been under the care of the writer in a general surgical block of a war hospital. Some 50 additional cases have been recorded since that date in the special military surgical section of the same hospital, and many others have passed under observation. A few of the latter are recorded in the text, but are not indicated in the statistical portion of the paper, which is concerned only with those admitted before April, 1918.

At the beginning no special method of recording nerve cases was adopted, but the effort to improve and standardize the records has culminated in the adoption of a case-record book for the specific purpose of recording the case-histories of nerve injuries. The book is composed of loose sheets, which are used as required.* Thus has been effected not only an economy in the labour of note-taking, but the certainty of a thorough and ordered examination of each case.

Every effort has been made to follow up the cases. Patients have not been invalided or discharged until all hopes of recovery have vanished, or until there were clear signs of improvement. After leaving hospital, many have been written to, and in other cases the medical attendants have been communicated with at the patients' homes. Some few have their homes in the district, and have attended over prolonged periods as out-patients; while several have journeyed considerable distances to be seen and examined. One patient was invalided to Canada, and returned to show himself 'cured' eighteen months after a partial neurectomy and suture (*Case* 12).

CLASSIFICATIONS OF CASES AND OPERATIONS.

Table I.—Showing the Number and Distribution of the Cases, and the Relative Frequency of Injury of Different Nerves in the Series.

Nerves Involved	No. of Cases	Relative Frequency of Injury	Percentage
Upper Limb			
Ulnar	23	36	21
Musculospiral	18	19	11
Median	17	30	18
Brachial plexus	13	13	7·5
Median and ulnar	11	—	—
Circumflex	2	2	1·5
Posterior interosseous	2	3	2
Musculocutaneous	1	1	1
Internal cutaneous	1	2	1·5
Suprascapular	1	1	1
Ulnar and posterior interosseous	1	—	—
Median, ulnar, and musculospiral	1	—	—
Median and internal cutaneous	1	—	—
Total	92	107	64·5
Lower Limb			
Sciatic, trunk	18	19	11
„ external division	12	13	7·5
Peroneal	7	8	4·5
Posterior tibial	6	8	4·5
Sciatic, internal division	3	3	2·5
Anterior crural	1	1	1
„ tibial	1	1	1
Obturator	1	1	1
Musculocutaneous	1	1	1
External saphenous	1	2	1·5
Peroneal and posterior tibial	1	—	—
Posterior tibial and external saphenous	1	—	—
Sciatic trunk (left) and sciatic external division (right)	1	—	—
Total	54	57	35·5
Other Nerves			
Supra-orbital	3	—	—
Cervical plexus	1	—	—
Total	4	—	—

* It had been intended to publish the Case Record Book as an appendix to this paper, but owing to the length of the article this has not been possible. The loose forms can be obtained from W. Tregaskis, 401, Oxford Road, Reading.

Table II.—NAMES OF THE NERVES, NUMBERS OF EACH INJURED, CLINICAL CLASSIFICATION, NUMBER OF OPERATIONS, AND OPERATIVE FINDINGS.

NERVE	No. of Cases	Clinical Classification	No.	Operated Upon	Operative Findings	No.
Median ..	30	Complete	8	7	Complete section	6
					Neuroma	1
		Incomplete	22	18	Complete section	1
					Neuroma	6
					Neuroma with lateral cicatrix ..	5
					Neuroma with circular cicatrix ..	1
					Lateral notch	1
					Neuroma with lateral notch ..	1
					Pressure of aneurysm	1
					Pressure of aneurysm with neuroma and lateral cicatrix ..	1
					Contusion*	1
Musculospiral ..	19	Complete	18	3	Complete section	3
		Incomplete	1	3	Neuroma with involvement in callus and lateral cicatrix ..	3
Ulnar ..	36	Complete	24	21	Complete section	17
					Neuroma with lateral cicatrix ..	3
					Neuroma with lateral notch ..	1
		Incomplete	12	6	Neuroma with lateral cicatrix ..	3
					Neuroma with circular cicatrix ..	1
					Pressure of aneurysm	2
Brachial plexus ..	13	See under special section dealing with brachial plexus		3	(1) Lateral cicatrix on ulnar and musculospiral	—
					(2) Pressure of aneurysm of axillary artery, with small lateral cicatrix of median	—
					(3) Pressure of aneurysm of axillary artery	—
Circumflex ..	2	Incomplete	2	0	—	—
Posterior interosseous	3	Complete	2	1	Involvement in callus	1
		Incomplete	1	0	—	—
Musculocutaneous	1	Complete	1	1	Involvement in scar	1
Internal cutaneous	2	Complete	1	1	Complete section	1
		Incomplete	1	1	Involvement in scar	1
Suprascapular ..	1	Incomplete	1	0	—	—
Sciatic, trunk ..	19	Complete	8	5	Complete section	3
					Involvement in scar	1
					Nothing macroscopically abnormal	1
		Incomplete	11	5	Neuroma with lateral cicatrix ..	2
					Involvement of sheath with new bone formation†	1
					Foreign body in nerve	1
					Irritation of bone fragments ..	1
Sciatic, external division	13	Complete	6	3	Complete section	2
					Neuroma with lateral cicatrix ..	1
		Incomplete	7	2	Neuroma with lateral cicatrix ..	2

* Operation at time of injury.

† Associated with traumatic myositis ossificans.

Table continued on opposite page.

Table II.—Continued.

Nerve	No. of Cases	Clinical Classification	No.	Operated Upon	Operative Findings	No.
Peroneal ..	8	Complete	6	4	Complete section	1
					Neuroma with lateral notch ..	1
					Neuroma and involvement in callus	1
					Pressure of stretching over deformed bone	1
		Incomplete	2	0	—	—
Posterior tibial ..	8	Complete	1	1	Neuroma with lateral cicatrix ..	1
		Incomplete	7	2	Neuroma with lateral notch ..	1
					Neuroma	1
Sciatic, internal division	3	Incomplete	3	3	Neuroma with lateral cicatrix ..	1
Anterior crural	1	Incomplete	1	1	Neuroma with lateral cicatrix ..	1
External saphenous	2	Complete	2	2	Complete section	2
Anterior tibial ..	1	Incomplete	1	0	—	—
Obturator ..	1	Incomplete	1	0	—	—
Musculocutaneous	1	Incomplete	1	0	—	—

Table III.—Summary of Table II.

(*Injuries of the Cervical and Brachial Plexuses and Cranial Nerves not included.*)

No. of Cases	Clinical Classification	No.	Operated Upon	Operative Findings	No.
151	Complete	77	49	Complete section	33
				Neuroma	3
				Neuroma with lateral cicatrix	5
				,, with lateral notch	2
				,, with involvement in callus	1
				Involvement in callus	1
				,, scar	2
				Stretching over deformity of bone	1
				Nothing abnormal found	1
	Incomplete	74	41	Complete section	1
				Neuroma	6
				,, with lateral cicatrix	16
				,, ,, circular cicatrix	1
				,, ,, lateral notch	2
				,, ,, involvement in callus and lateral cicatrix	3
				Lateral notch	3
				Involvement in new bone formation	1
				,, scar	1
				Foreign body in nerve	1
				Irritation of bone fragments	1
				Pressure of aneurysm	3
				,, ,, with neuroma and lateral cicatrix	1
				Contusion	1

Number of nerves analysed, 151. Number of operations, 90 (= 60 per cent).

Table IV.—Showing the Operations Performed, and Numbers of each.

Operation	No.
Delayed suture	23
Total exsection and suture	6
Partial exsection and suture	7
Neurolysis	39
Autogenous transplantation	4
Total exsection and autogenous transplantation	1
Homologous transplantation	1
Double lateral implantation	3
Exploration	6
Total ..	90

ILLUSTRATIVE CASES.

1. NERVE TRANSPLANTS AND DOUBLE LATERAL IMPLANTATIONS.*

This group comprises 5 ulnar, 1 median, 1 sciatic, and 1 posterior tibial lesions in which end-to-end union could not be obtained on account of the long gap between the divided ends.

Of these, two of the ulnar, and the median, sciatic, and posterior tibial cases, were dealt with by autogenous transplants from the radial. One ulnar case was bridged by a homologous transplant of external popliteal nerve. The two remaining ulnar cases were dealt with by double lateral implantation of the divided ends into the median nerve in the forearm.

As nerve grafting has been stated to be of little value, and nerve anastomosis has been condemned,[1] these cases are worth examining in some detail.

A. NERVE TRANSPLANTS.

Case 1.—Pte. T., age 22. Bullet wound of upper third of right forearm, August, 1915. Clinical diagnosis: (1) Complete division of ulnar; (2) Complete division of posterior interosseous.

Operation, Nov. 11.—Complete section of ulnar nerve. Bulb on central end resected until healthy fasciculi were visible. Lower end dealt with similarly. Gap of 5 cm. separating ends, reduced to 2·5 cm. by flexing wrist. Gap bridged by two pieces of radial nerve each 2·5 cm. long removed from forearm (*Fig.* 345). Suture line and transplant wrapped in Cargile membrane. Posterior interosseous nerve freed from callus and wrapped in Cargile membrane.

Fig. 345.—*Case* 1.

Complete section of ulnar in forearm, bridged by two auto-transplants of radial.

Dec. 27: Pin-prick felt on ulnar half of ring finger and over small area on radial side of little finger.

Feb. 16, 1916: Pin-prick everywhere appreciated in palm of hand and radial side of little finger.

March 3, 1918: Painful spots to pin-prick scattered freely over little finger, but pin-prick not everywhere felt. Epicritic sensation defective in little finger. No alteration from normal detected in ring finger nor in that part of hand supplied by ulnar. No loss of sensation in radial area. Formication not obtained, but hypothenar muscles sensitive to pinching. Scarcely any wasting of hypothenar eminence. Interossei still slightly wasted, but much improved, and "still filling out." Hollow between metacarpals of thumb and index finger less evident. Slight, reducible clawing of little finger. Pitre's tests possible, but imperfectly compared with normal hand. Flexor profundus to little and ring fingers, and flexor carpi ulnaris, act normally (lesion below level

* Instead of the name 'nerve grafting,' the writer has followed Sherren in his preference for the term 'nerve transplantation.'

of the branches to these muscles). Extensors of wrist, thumb, and fingers all act normally. Electrical examination: No faradic response in muscles supplied by ulnar or posterior interosseous nerve below level of lesion; extensor muscles react briskly to galvanism; ulnar muscles react well; no polar change.

Summary.—Transplant of two pieces of radial into ulnar. Partial motor and sensory recovery in 28 months.

Case 2.—Pens. A., age 32. Wounded in lower third of left arm, Nov. 8, 1914. Admitted Sept. 23, 1916, with complete ulnar division. Hand neglected, with severe contractures, not relaxing under anæsthetic.

Operation, Oct. 23.—Complete section of ulnar. Resection of bulbs on the central and peripheral segments. Gap of 7·5 cm. remained, reduced to 3·6 cm. by stretching and extending arm. One piece of radial nerve transplanted into gap (*Fig.* 346).

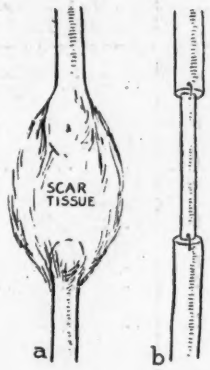

FIG. 346.—*Case* 2.

a. Complete division of ulnar. *b*. Gap bridged by autotransplant of radial.

March 20, 1917: Formication on percussion over line of union of transplant with upper segment. Transplant can be felt as a continuous cord in line of nerve. At both ends of transplant a spindle-shaped bulb can be felt.

May 20: Formication produced by percussion along nerve as low as mid forearm, beginning opposite lower end of transplant. Bulb at upper end of transplant has not apparently altered in size, but percussion over it does not produce formication. Return of protopathic sensation over ulnar side of ring finger.

FIG. 347.—*Case* 3.

Compound fracture of femur, before and after plating. Complete division of sciatic, which was involved in callus.

Feb. 25, 1918: Formication to percussion from mid forearm to hypothenar eminence. Flexor carpi ulnaris and flexor profundus digitorum to ring and little fingers act voluntarily and respond to faradism. No return of motor power or faradic response in small muscles of hand. Clawing of ring and little fingers has considerably increased in response to motor recovery of flexor profundus. Bulbs at junction of upper and lower ends of transplant with nerve can still be distinctly felt, and transplant itself is palpable as a rounded cord, comparable in size with the nerve above and below, and freely movable from side to side.

Summary.—Transplant of radial into ulnar above elbow. Formation of bulbs at both ends of transplant in 5 months. Formication to mid forearm in 7 months. Partial motor and sensory recovery in 16 months.

Case 3.—Pte. K., age 21. Bullet wound of left thigh, with compound fracture of middle of femur, July 1, 1916 (*Fig.* 347). Complete division of sciatic nerve.

Aug. 16: Femur plated.

Operation, Nov. 11.—Sciatic found destroyed for 7·5 cm. Both ends bulbous and involved

in large bone callus. After stretching and resection, gap of 2·5 cm. remained. Slight flexion only of knee allowed by stiffness. Gap bridged by three pieces of radial nerve removed from both forearms (*Fig.* 348). Bridge surrounded with Cargile membrane.

Nov. 21: Trophic sores on great toe and inner side of foot.

April 10, 1917: Diminished loss of protopathic sensation. Formication on percussion at apex of popliteal space, i.e., below level of transplant.

May 15: Formication on percussion over lower end of popliteal space and head of fibula. A large oval swelling can be felt by deep palpation of thigh at level of injury. Trophic sores have healed.

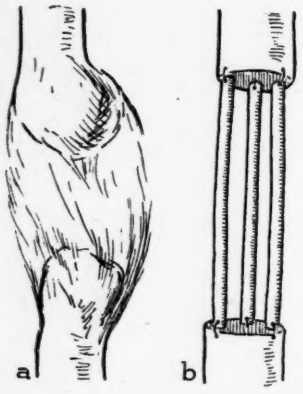

FIG. 348.—*Case* 3.

a. Complete division of sciatic. *b.* Gap bridged by three autotransplants of radial.

February, 1918: Pin-prick still not felt on foot in sensory areas of external and internal popliteal. Paralysis with R.D. of anterior tibial and peroneal muscles. Good voluntary movements in gastrocnemii and soleus, which react to faradism.

Summary.—Three transplants of radial into sciatic. Partial motor and sensory recovery in 15 months.

Cases 4 and 5.—These were the median at the wrist and the posterior tibial above the ankle. In both, a gap was bridged with an autogenous transplant of the radial. In both, six months later, there was considerable diminution in loss of protopathic sensation and formication to percussion below level of transplant. In neither case had voluntary power returned in muscles supplied by the nerves. *Case* 5 had been explored for pain, without benefit, four months previously, when a large neuroma was found, which was wrapped in Cargile membrane. At a second operation the large neuroma was excised, the Cargile membrane was found practically absorbed, and the nerve was lying free from adhesions.

Summary.—Transplants of radial into median and posterior tibial. Some sensory recovery in 6 months. Cargile membrane nearly absorbed after 4 months.

A further case throwing light on some of the problems of nerve transplantations, but not included in the statistical cases, was that of a youth who had had elsewhere a portion of his radial transplanted into a gap in the ulnar in the upper third of the right forearm a year previously, without any recovery of sensation or motor power.

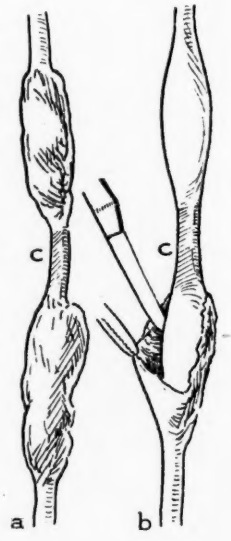

FIG. 349.—*Case* 6.

Complete division of ulnar with autotransplant from radial. *a.* One year after first operation, showing hypertrophy of transplant and formation of spindles. *b.* Neurolysis capsulectomy. *c.* Transplant.

Case 6.—Pte. P., age 19. Bullet wound of upper third of left forearm, Jan. 20, 1917.

Operation, July: Complete section of ulnar. Gap of 3·5 cm. bridged by autotransplant of radial.

August, 1918: Complete paralysis with R.D. of ulnar muscles, and complete sensory loss (*Fig.* 350).

Operation, August, 1918.—Explored. Large oval bulb forming a typical neuroma, densely adherent to surrounding muscles, was found at upper end of transplant. Bulb tapered into transplant, which, although tightly compressed by dense scar, was seen when liberated to resemble normal nerve in size, shape, and consistency. A smaller but similar bulb was found at lower end of transplant, which tapered off into nerve below. The transplant, originally a portion of the radial, had hypertrophied until it equalled in size the nerve into which it had been transplanted (*Fig.* 349).

October: Four months after neurolysis, formication elicited at point 5 cm. above wrist—a spread downwards of 170 mm. in 79 days. Protopathic sensation completely returned over ulnar side of ring finger (*Fig.* 350).

Summary.—Autogenous transplant of radial into ulnar. Formation of bulbs and hypertrophy of transplant, but no recovery, in 13 months. Some sensory recovery and progress of formication 2 months after neurolysis.

Case 7.—Pte. G., age 36. Shell wound of right elbow, March 15, 1917. Severe comminution of upper end of ulna implicating elbow-joint, which had been partially excised. Complete division of ulnar nerve.

Operation Jan. 5, 1918.—Twelve centimetres of ulnar nerve completely destroyed. Upper and lower segments translated to front of elbow, and joint flexed. Gap of 7·5 c.m. Bridge of 7·5 cm. of external popliteal nerve, previously removed from case of irreparable injury to anterior tibial and peroneal nerves (*Fig.* 351). Catgut not being available, sutures of fine black thread were used. Cargile-membrane covering.

August: No recovery of sensation to pin-prick. Formication on percussion not elicited below upper level of transplant. No sign of motor recovery.

Second Operation, August 5.—Nerve explored. Upper segment found swollen and ending in a large soft spindle-shaped neuroma at its junction with transplant. Black-thread sutures still visible, occupying position of greatest diameter of bulb. Cargile membrane completely absorbed. Passing downwards, transplant retained its shape, colour, and individuality. Near lower end transplant rather thinned. Transplant as a whole rather flatter and smaller than nerve into which it had been transplanted. A second neuroma—smaller than the upper one—was found at junction of transplant with lower segment. Here again the black-thread sutures were in the position of the greatest diameter of the bulb. No conduction of faradic current through transplant. The transplant, which originally had a larger diameter than that of the ulnar nerve, had slightly but quite definitely wasted. Bulbs and transplant freed from scar tissue (*Fig.* 351).

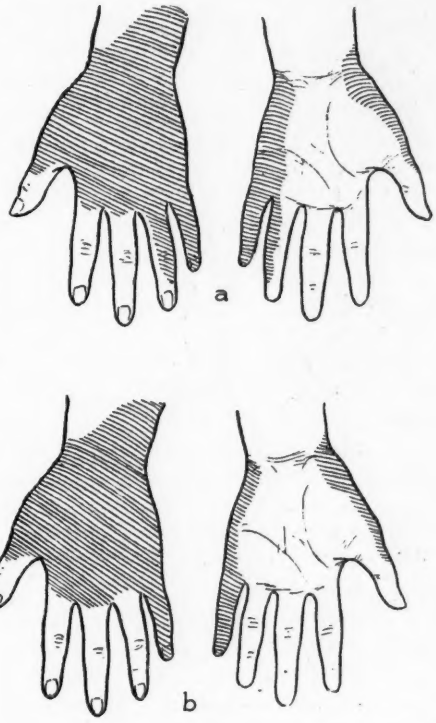

FIG. 350.—*Case* 6.

a. Showing loss of sensation from complete division of ulnar, bridged by 3·5 cm. of radial from upper third of forearm, one year after operation.

b. Extent of recovery of protopathic sensation two months after neurolysis capsulectomy.

October: Formication to percussion 5 cm. below lower end of transplant.

Summary.—Homologous transplant of external popliteal into ulnar. Formation of spindles, involving nerve and transplant at both ends. Wasting of transplant. No recovery in 7 months. Progressive formication below level of transplant 2 months after neurolysis.

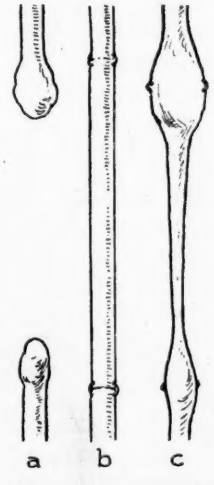

FIG. 351.—*Case* 7.

a. Complete division of ulnar, with gap of 7·5 cm. *b*. Gap bridged with homologous transplant of external popliteal. *c*. Seven months later, showing formation of spindles at both ends of transplant, and position of black-thread sutures.

Nerve transplantation has had a sound experimental basis since the experiments of Phillipeaux and Vulpian in 1870, and has been employed in treatment with satisfactory results since 1888. Mayo Robson[2] operated upon and reported the first successful case. Owing to the War, many opportunities for nerve transplantation have presented themselves, but there is still some difference of opinion on the value of the operation. Thus, Moynihan[1] writes, "Nerve grafting is of little value," and Rawling[3] says, "Grafting, implantation, etc., are comparatively useless." On the other hand, Jocelyn Swan[4] reports two cases of motor recovery following nerve grafts, and says, "I think it is a mistake to damn nerve grafting where the ends cannot be approximated, a state of things which is bound to occur to surgeons who see many of these cases." Among the French school, Benisty[5]

says, "The results of nerve grafting, which *a priori* appears to be a logical procedure, cannot yet be appreciated, since regeneration is beset with difficulties and takes place but slowly." On the other hand, Delagenière[6] reports from Tinel's clinic 9 cases of musculospiral grafts with 3 almost complete successes.

Cases 2 and 3 show that both sensory and motor recovery do occur after nerve transplantation, although in neither case was recovery complete. *Cases* 4 and 5 have improved, while in *Cases* 6 and 7 axis cylinders have now penetrated into the lower segments. Even a measure of recovery is better than none at all, and it has yet to be seen whether one or more of these cases will not ultimately recover completely. Recovery after a nerve transplantation certainly occurs much more slowly than after an end-to-end suture; but the writer agrees with Swan that it is a mistake to condemn nerve transplantation, and believes that with a larger knowledge of the processes involved, and a wider experience of technical details, the results of nerve transplantation are likely to compare favourably with those of end-to-end suture.

Apart from the possibility of recovery after nerve transplantation, the seven cases described possess many other points of theoretical and practical interest. Thus, *Cases* 2 and 6 show—the first by palpation, the second by inspection—that autogenous grafts hypertrophy and may ultimately grow to the same size as the nerve into which they are transplanted; while in *Case* 7 a homologous transplant, originally larger than the receiving nerve, diminished in size.

Cases 2, 6, and 7 show how transplants unite with the receiving nerve at either end by the formation of spindle-shaped neuromata, the larger at the central end. In all these cases the bulb at the lower end of the transplant had formed before any signs could be detected that axis cylinders had reached this level from the central segment.

Case 7 demonstrated by the position of the black-thread sutures that the neuromata were formed partly in the original nerve ends and partly in the ends of the transplant, and suggested that not only the nerve but the transplant had a share in their production.

In *Case* 6, five months elapsed before formication was elicited by percussion at a lower level than the transplant. Thereafter it spread with comparative rapidity down the distal segment of the nerve.

In *Case* 3, there could be detected by palpation a large neuroma which from its size must have involved both ends of the nerve as well as the three transplants. Through the medium of this neuroma regeneration of the distal segment occurred, and motor recovery in certain of the muscles ensued.

In *Cases* 6 and 7, the constricting effect of the surrounding scar was the important factor in preventing recovery. After its removal, neurotization of the transplant and lower segment occurred quickly.

B. DOUBLE LATERAL IMPLANTATIONS.

While nerve transplantation has been damned by faint praise, the operation of double lateral implantation has, by the majority of writers on the surgical treatment of nerve injuries, been directly condemned. Thus, Benisty, speaking of operations which "must be rejected as illogical," especially mentions "the grafting of the central end on to a healthy neighbouring nerve, or the peripheral end on to a neighbouring mixed nerve." Moynihan writes, "Nerve anastomosis is to be sharply condemned." Tinel writes, "Lateral implantations, transplantations of one nerve into the other, are almost always useless, and often mischievous, operations."

In what follows, the writer refers to the special case of double lateral implantation of the ulnar into the median in the forearm. In this particular case the operation is not only harmless, but when the ulnar nerve in the forearm has been destroyed over a wide extent, is capable of producing good results. Three cases of this operation have been performed, but only one has been followed long enough to speak of the ultimate result. The other two confirm the view that the operation is a harmless one.

Case 8.—Pte. F., age 25. Shell wound of left forearm, May 28, 1915. In hospital at home 6 weeks.

July: Sent to Gallipoli.

December: Returned to England with enteric.

January, 1916: Admitted with advanced irreducible clawing of all fingers. Complete ulnar division, complicated by a Volkmann's ischæmic contracture.

Operation, February.—Ten centimetres of ulnar nerve totally destroyed. Well-formed bulb at central end. Resection of bulbs and excision of intervening scar—gap 13 cm. Approximately one-third of circumference of median on ulnar side was divided at two points 16 cm. apart. Upper and lower ends of ulnar implanted into the median in manner shown in *Fig.* 352.

Day following: Loss of sensation to cotton-wool over median area of ring, middle, and index fingers. Sensation to pin-prick lost over radial half of ring finger, middle finger, and ulnar half of index finger (*Fig.* 353). Thumb not affected. Opponens pollicis, abductor brevis pollicis, and first lumbrical acting normally.

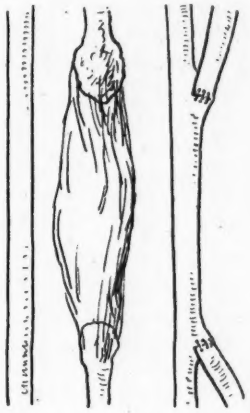

FIG. 352.—*Case* 8.

Double lateral implantation of ulnar into median.

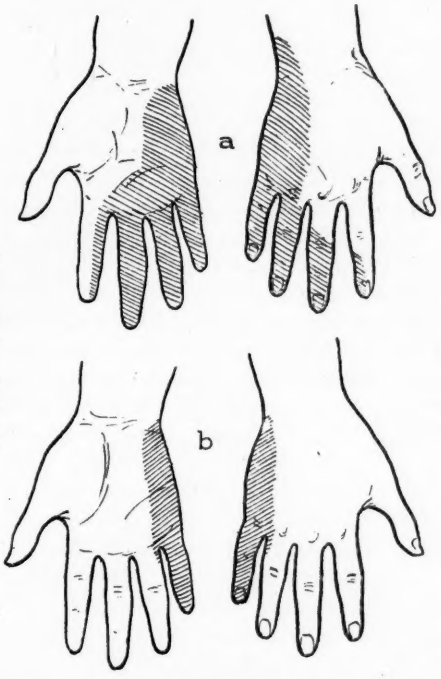

FIG. 353.—*Case* 8.

a. Sensory loss to pin-prick after double lateral implantation involving division of ulnar third of median nerve in forearm at two points 15 cm. apart. *b.* Extent of recovery after 6 months.

April: Flexor contracture of fingers increased.

Operation, April.—Superficial and deep flexors of fingers lengthened. Distal implantation examined. Where distal segment of ulnar joined median, there was a small but distinct bulb, olive-shaped, and involving approximately equal amounts of the two nerves (*Fig.* 354).

August: No recovery of motor power in ulnar muscles. Pin-prick perfectly appreciated in whole of index and middle fingers, over radial half of ring finger, and near base of ring finger on ulnar side (*Fig.* 353).

FIG. 354.—*Case* 8.

Showing formation of spindle involving both nerves at lower end of double lateral implantation into median.

Although unable to examine this case again, the writer has heard by letter from the patient; and Sir Thomas Myles, Consulting Surgeon, Irish Command, kindly made inquiries and sent a letter from the patient's medical officer, Mr. E. D. Thompson. The following are extracts from their letters:—

Extract from letter from patient, dated Nov. 28, 1917.—

> "I have nearly all the feeling restored to my hand, the most sensitive being the little finger. It would be quite surprising to you to see how the hand has improved since your operation."

Extract from letter to Sir Thomas Myles from Mr. E. D. Thompson, dated Feb. 9, 1918.—

> "The man is wonderfully well. He can close all his fingers, and give a good grip. He has also uniform sensation in both back and front of hand. He can pick up a pin quite easily. The feeling is not quite as good as in his right hand, but he says both the power and sensation are getting better."

Summary.—Double lateral implantation of ulnar into median in forearm, followed by some sensory loss in median area. Recovery of sensibility to pin-prick in median area in 6 months. Some motor and sensory recovery in ulnar area in 24 months.

FIG. 355.

Diagram representing pedicled neurovascular autotransplant (shaded portion) in a case of double lateral implantation of divided nerve into a neighbouring healthy nerve trunk.

The writer is aware that proof of regeneration in the distal segment of the ulnar in the above case is not complete, but the man is still in the Army, and has a useful hand.

The two other cases operated on in this manner have not been watched long enough to report on the result; but in neither case was there any greater loss of sensation in the fingers from dividing a third of the circumference of the median on the ulnar side than has been recorded in *Case* 8. The fact that the ulnar third of the circumference of the median nerve in the forearm subserves sensation only in the ring, middle, and index fingers has been confirmed by the writer on many occasions in cases of incomplete division of this nerve explored by operation.

Instead of regarding the operation as an illogical procedure, the writer believes that the portion of the median nerve between the two lateral cuts acts as a pedicled neurovascular autotransplant (*Fig.* 355), and is more likely to succeed than a free autotransplant.

2. SUTURES.

The following has been the method of suture in the majority of cases. A long skin incision is made, any dense adherent scars being excised whenever possible. Small sterilized cloths, to the under side of which is sewn a layer of jaconet, are clipped to the subcutaneous fascia so as to exclude completely skin contamination of sutures, swabs, and instruments for the remainder of the operation. The upper end of the nerve is usually defined first, and the bulb carefully dissected from adhesions to the surrounding structures. The lower end is then sought, found, and dealt with in the same way. The intervening scar is carefully excised. All the chief bleeding points are ligatured, and all oozing is checked by gauze pressure, oversewing, or by swabbing out the wound with warm peroxide of hydrogen (5 vols.) or adrenalin (1–1000). A great point is made of obtaining a dry wound before proceeding with the next stage of the operation.

When the wound is quite dry, the gap between the divided ends is carefully measured, and a rough estimation made of what this will be when the end bulbs have been resected. The proximal end of the nerve is now stretched, and a decision made whether any other steps are necessary in order to bring the ends together without tension. If such be the case, these are then carried out.

The bulb on the central end is now removed in successive slices with a sharp knife until healthy nerve fasciculi are seen protruding from the cut face of the nerve. A similar resection of the distal segment is made. A tension suture of fine catgut is now passed through the centre of both segments, and the ends are drawn together. Two continuous sutures of the finest catgut procurable draw the sheath together, one suture being used for each half of the circumference of the nerve. At this stage the tension suture is generally removed, but if there has been any difficulty in drawing the ends of the nerve together, it is tied and left *in situ*.

The suture line, and the nerve for 2½ cm. on either side, have been in many cases wrapped in Cargile membrane. The membrane, which has been placed in 1–500 perchloride of mercury at the beginning of the operation, is thoroughly washed in normal saline, and a piece 5 cm. long and one and a half times as broad as the circumference of the nerve, is cut and insinuated under the nerve. The membrane is then carefully

wrapped round the nerve. In some cases, free or pedunculated flaps of fat or fascia have been used as a covering. In others no protection has been used, the nerve being placed between healthy muscles, with or without smearing the suture line with sterilized paraffin.

The muscles, which have been drawn out of the way with retractors, are now allowed to fall into position, and the deep and superficial fascia is carefully closed with catgut sutures. The skin is closed with interrupted salmon-gut sutures.

This method is not original; similar procedures have been described by many other workers; but in order that certain points in technique may be discussed in view of the results obtained, it has been described in some detail.

One of the difficulties in comparing results in nerve work is to know what is meant by such terms as 'recovery,' 'improvement,' etc. It is quite certain that after delayed nerve suture, complete recovery, in the sense that no differences can be found between the normal and affected limb, is seldom if ever attained; there remains an incomplete recovery of the finer forms of sensation, some slight wasting of the affected muscles, or a greater liability to fatigue on the affected side. In order, however, to tabulate and compare results, the use of such terms is necessary; and in what follows, the terms 'Recovery,' 'Considerable improvement' 'Improvement,' and 'No result' are used.

'Recovery' denotes complete return of protopathic sensation, recovery of useful voluntary movements in all the affected muscles, with return of faradic response.

'Considerable improvement' denotes complete return of protopathic sensation, recovery of some voluntary movements in affected muscles, with or without response to faradism.

'Improvement' denotes some return of protopathic sensation, with or without early voluntary twitchings of one or more of the affected muscles, with or without response to faradism, and definite and progressive formication on percussion over the nerve below the level of the lesion.

'No result' comprises all other cases, and includes cases lost sight of or transferred to other hospitals before sufficient time has elapsed to estimate the result; all doubtful cases; and cases watched sufficiently long without any sign of recovery to be classified as failures.

The following table shows the results obtained in a total of 36 cases, made up of 23 cases of delayed suture of completely sectioned nerves, 6 cases of total exsection of affected segments followed by suture, and 7 cases of partial exsections of affected nerves followed by suture.

Table V.—Results of 36 Cases of Nerve Suture.

	Recoveries	Considerable Improvement	Improvement	No Result†
Number of cases	8	6	8	14
Percentage	23	14	23	40
Average time between wound and operation ..	5 months	6 months	8 months*	—
Average time under observation since operation	15 „	7 „	3 „	7 months
Longest time „ „ ..	24 „	12 „	7 „	24 „
Shortest time „ „ ..	8 „	4 „	1 „	1 „

* Leaving out one case sutured 2 years and 5 months after injury, average time between wound and operation = 5 months.

† *Analysis of 'No Result' Cases.*—
Failures: Those seen 7 months or longer after operation with no sign of recovery 5
Average time from wound to operation .. .. 10 months
(Excluding one case of 19 months, average time between wound and operation = 7 months.)
Average time since operation .. .. 11 months
Doubtful: Cases earlier than 7 months after operation with no sign of recovery 9

A. RECOVERED CASES.

The following case illustrates the successive stages of recovery, and is remarkable in its successful issue after ligature of the main vessel of the limb.

Case 9.—Gnr. M., age 22. Shell wound of left popliteal space, May 24, 1915. Common femoral artery tied in a field hospital.

June 1: Admitted with severely suppurating wound behind knee. Foot and ankle œdematous. No pulse palpable at ankle. Black gangrenous patch of skin on point of heel. Complete paralysis with R.D. of all muscles below knee. No sensibility to pin-prick or brush in external or internal popliteal sensory areas.

Oct. 20: Nerve condition unaltered. Wounds have been healed four weeks.

Operation, Oct. 23.—Complete section of both internal and external popliteal nerves with end bulbs. Gap of 3·6 cm. Sutured. Free sleeve of fascia lata.

December: Partial recovery of protopathic sensibility. Ulcer on heel smaller.

March, 1916: Slight voluntary twitchings in gastrocnemii and tibialis anticus.

June: Weak voluntary movements of flexion and extension of foot. Ulcer on heel well. Protopathic sensibility recovered. Sensibility to brush nearly recovered except over toes.

October, 1917: Left leg still slightly smaller than right. Complete recovery of voluntary power in all muscles, with normal electrical responses. Is walking about all day. Left leg becomes slightly more fatigued than right.

Summary.—Improvement in 3 months. Considerable improvement in 8 months. Recovery in 24 months.

Another sciatic case of very similar type to the foregoing deserves recording, owing to the very rapid recovery which followed suture 11 months after the nerve had been divided.

Case 10.—Pte. P., age 20. Shell wound of left thigh, Aug. 6, 1916.

January, 1917: Admitted from his depôt with trophic ulcer of great toe, complete paralysis with R.D. of all muscles below knee, and no sensibility to pin-prick or cotton-wool in external or internal popliteal sensory areas. Refused operation until July, 1917. Nerve condition unaltered.

Operation, July 3.—Condition shown in *Fig.* 356. Nerve stretched, bulbous extremities resected. Knee flexed. Suture. Cargile-membrane protection. After 4 weeks knee gradually extended.

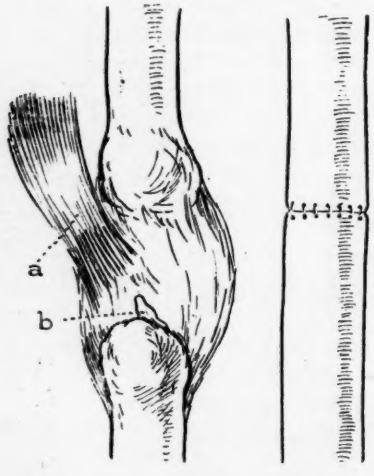

FIG. 356.—*Case* 10.

Condition before and after operation. *a*. Muscle drawn in between divided ends. *b*. Bony projection from posterior surface of femur.

Dec. 9: Voluntary power in calf muscles. Sensibility to pin-prick and brush recovering rapidly. Formication on percussion half-way between knee and ankle, 360 mm. in 160 days—over 2 mm. per day.

June, 1918: Voluntary power strong in calf muscles. Sensibility to pin-prick and brush completely recovered. Trophic ulcer healed.

October: Continued improvement, with return of faradic response and voluntary power in all muscles below knee.

Summary.—Improvement in 5 months. Considerable improvement in 11 months. Recovered in 15 months. Formication to percussion spread down nerve at a rate exceeding 2 mm. per day.

The individuality of nerves from the point of view of the rapidity and completeness with which they regain their motor power, noticed by several writers, was first pointed out by Réné Dumas,[7] but he was disappointed in the sciatic nerve from this point of view. In the writer's experience, the sciatic nerve and both its internal and external divisions, are in this respect second only to the musculospiral.

In four cases recovery followed suture of the external division of the sciatic.

Case 11.—Pte. S., age 19. Shell wound of left thigh, July, 1916. Complete paralysis of anterior tibial and peroneal muscles, with R.D. Pain and tenderness on dorsum of foot, and hyperæsthesia to pin-prick. Sensibility to cotton-wool blunted.

January, 1917: Condition unaltered.

Operation, Jan. 6.—Lateral notch in external division of sciatic, with bulb of upper segment (*Fig.* 357). Resection and suture. Cargile membrane. Knee flexed.

June: Sensibility to pin-prick recovered. Formication on percussion 5 cm. above external malleolus 440 mm.—average over 2 mm. per day. Slight voluntary power in peroneii and common extensor.

January, 1918: Still improving. Voluntary power in tibialis anticus.

May: Severe attack of pneumonia. Foot left unsupported.

June: Voluntary power in anterior tibial group lost.

August: Voluntary power has returned in all muscles supplied by external popliteal nerve.

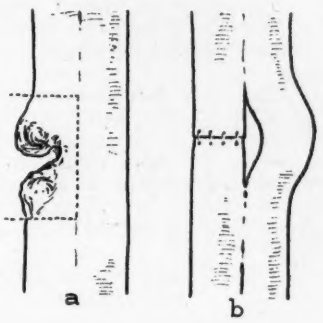

FIG. 357.—*Case* 11.

Lateral notch of external division of sciatic. *a*. Before, *b*. After resection suture.

Summary.—Recovered in 20 months. Recovery interrupted by pneumonia. Formication progressed at rate exceeding 2 mm. per day.

Case 12.—Sgt. P., age 30. Through-and-through bullet wound of left thigh and groin, September, 1916.

November: Complete paralysis with R.D. and sensory loss in external popliteal. Paralysis with R.D. in calf muscles. Voluntary power in small muscles of foot. Excruciating pain in sole of foot.

Operation, Nov. 18.—Nerve damaged at level of gluteal fold (*Fig* 358). Partial exsection and suture. Cargile membrane. Flexion of knee.

February, 1917: Pain and tenderness gone. Sensation in sole of foot normal. Voluntary power in small muscles of foot. No recovery in sensory area of external popliteal. All muscles of leg still paralyzed. Invalided to Canada.

June, 1918: Returned for examination. Voluntary power and faradic response in all muscles of leg. No loss of sensibility to pin-prick or cotton-wool.

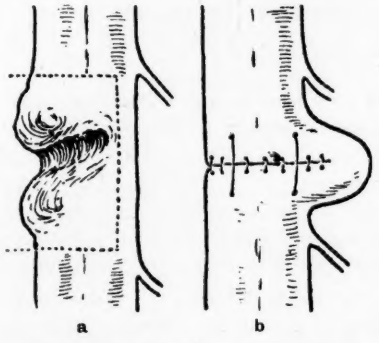

FIG. 358.—*Case* 12.

Lateral notch of sciatic trunk. *a*. Before, *b*. After partial resection suture. Topography of sensory fibres to sole of foot shown on inner side of nerve.

Summary.—Sensory nerve fibres to sole of foot and motor fibres to small muscles of foot located on internal aspect of internal division of sciatic. Recovery after 20 months.

FIG. 359.—*Case* 13.

Lateral notch of external popliteal before and after resection suture.

Case 13.—Pte. B., age 26. Multiple shrapnel wounds of right leg and thigh, July, 1916.

December: Paralysis with R.D. in all muscles supplied by external popliteal except the tibialis anticus.

Operation, Dec. 14.—Deep lateral notch, with bulb of upper segment, on deep aspect of nerve (*Fig.* 359). Partial resection and suture. Cargile-membrane protection.

May, 1917: Tenotomy of Achilles tendon. Foot retained at right angle in plaster.

August: Voluntary power in all muscles of leg, with faradic response. Can walk well.

Summary.—Recovery after 8 months.

Case 14.—Pte. W., age 27. Bullet wound of right leg, with compound fracture of fibula, July 1, 1916. Complete paralysis with R.D. in all muscles supplied by external popliteal, with corresponding sensory loss.

September: Piece of shrapnel removed from head of fibula. Sinus excised. B.I.P.P. Sutured. Primary union.

March, 1917: No recovery.

Operation, March 8.—Nerve densely bound down and surrounded with callus (*Fig.* 360).

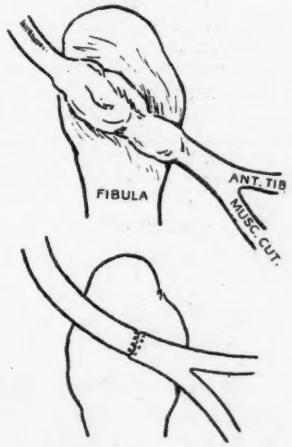

FIG. 360.—*Case* 14.

Complete division of peroneal nerve, with involvement of bulbs and callus. Before and after operation.

Involved part of nerve occupied by hard (? fibrous) mass. Total exsection and suture. Cargile membrane.

May 5: Formication 12 cm. below level of suture. Invalided.

June, 1918, by letter: Complete recovery. Able to raise foot easily and walks well.

Summary.—Average progress of formication in 2 months after suture, 2 mm. per diem. Recovery in 15 months.

The next case is an example of severe causalgia of the median, relieved by exsection and suture.

Case 15.—Cpl. T., age 35. Shrapnel wound of bend of right elbow, September, 1915. No paralysis in median. Severe pain in right hand.

November: Pain has become unbearable. Insomnia. Threatens to commit suicide. Skin of hand dry. Fingers thin, slender, and stiff from disuse. Nails long and bent.

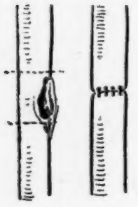

FIG. 361.—*Case* 15.

Lateral neuroma of median, causing causalgia. Total exsection and suture.

Operation, November.—Lateral neuroma (*Fig.* 361). Total exsection and suture. Cargile membrane. Elbow flexed.

January, 1916: Rapid recovery of sensation. Cotton-wool and pin-prick everywhere felt in median area except on ulnar side and dorsal surface of middle phalanx, the insensitive area being mapped out by a patch of undesquamated epithelium.

May: Weak voluntary power in all muscles supplied by median, with exception of small muscles of hand. Spindle-shaped swelling easily palpable in course of nerve at level of suture.

March, 1917: Voluntary power in all muscles.

November: Hand practically normal, except still slightly tender in cold weather.

Summary.—Considerable improvement, with formation of nerve spindle, in 7 months. Recovery in 24 months.

The last recovered case is one of complete section of the musculospiral, and is one of the only two examples of suture of this nerve in the series. Three reasons account for the relative rarity of suture of the musculospiral. They are: (1) The ease with which this nerve recovers from lesions other than complete section, either spontaneously, or after a neurolysis; (2) The frequent association of injuries of the nerve with severe fractures of humerus (15 out of 19 cases in this series), followed by extensive formation of callus, making nerve suture difficult and uncertain; (3) The alternative operation for this nerve described by Major-General Sir R. Jones,[8] which, if not the operation of choice, gives results little if at all inferior to those of nerve suture, and in much less time. The case illustrates the bad effect of prolonged extension of the fingers at the metacarpo-phalangeal joints.

Case 16.—Bbdr. S., age 24. Shrapnel wound of left upper arm, November, 1915. Complete paralysis of supinator longus and brevis, and all extensor muscles of forearm, with R.D. No sensory alteration.

Operation, January, 1916.—Three pieces of shrapnel removed. Nerve completely divided in groove, and buried in very dense scar. Suture and Cargile-membrane protection.

May: Voluntary twitchings of extensors of wrist and fingers. Fingers stiff at metacarpo-phalangeal joints from hyperextension on long cock-up splint.

March, 1917, by letter: "My arm is progressing wonderfully. I can raise my wrist up and down. I have got more power in my thumb and first two fingers. I cannot bend my little and third fingers."

Summary.—Improvement in 4 months. Recovery in 14 months.

B. CONSIDERABLY IMPROVED CASES.

The cases of 'considerable improvement' are 3 ulnar lesions, 2 median, and 1 anterior crural.

Most writers are agreed that the ulnar recovers slowly and with difficulty, and the hypothesis has been put forward that this is due to distortion of the nerve pattern. Thus, Gwynne Williams,[9] comparing the results of suture of the musculospiral nerve with those of suture of the median or ulnar, concludes that it must be the composition of the nerve that makes the difference. Two of the three cases which follow suggest that one must look to the small muscles of the hand for the difficulty in recovery. Motor power in the flexor carpi ulnaris and flexor profundus digitorum returns as easily after suture

of the ulnar as it does in the radial extensors after suture of the musculospiral. The slow recovery of the small muscles of the hand may possibly be due to the difficulty of keeping them efficiently relaxed; or it may be explicable on grounds of an inherent property of the muscles themselves, in some way associated with the highly complex movements which they have to execute. The small size of their fleshy bellies may also be a factor of importance.

Case 17.—F. L., age 14. Severe cut of left forearm 7·5 cm. below elbow, March, 1917.

October: Complete paralysis of all ulnar muscles with R.D. and sensory loss in ulnar area. Voluntary power in flexor carpi ulnaris and ulnar half of flexor profundus. Claw hand.

Operation, October, 1917.—Complete section found. Suture. Protection with Cargile membrane and vaseline. Nerve translated to front of elbow, and elbow flexed.

October, 1918: Pin-prick everywhere recovered. Voluntary power in all small muscles of hand. Still loss of finer sensation in little finger.

Summary.—Considerable improvement after 12 months. (Note patient's age.)

Case 18.—Cpl. F., age 29. Shell wound of lower third of left arm, with compound fracture of humerus and injury to ulnar nerve, February, 1918.

June: Complete paralysis with R.D. of all ulnar muscles below elbow. Slight, reducible claw hand. Loss of sensibility to pin-prick and brush in ulnar area. Loss to pin-prick greater than loss to brush.

Operation, June 20.—As in *Fig.* 362.

Aug. 26: Formication to two finger-breadths above wrist—190 mm., an average spread of 2·8 mm. per diem. Protopathic sensation recovering rapidly.

October: Voluntary power in flexor carpi ulnaris, with return of faradic response. Voluntary power in flexor profundus, but still R.D. No return of voluntary power in small muscles of hand. Fingers clawed if splint is removed.

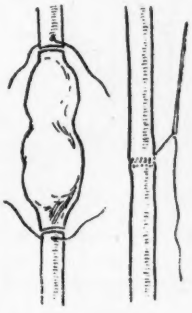

FIG. 362.—*Case* 18.

Before and after exsection and suture.

Summary.—Recovery of voluntary power in flexor carpi ulnaris and flexor profundus digitorum in 4 months.

FIG. 363.—*Case* 19.

a. Five centimetres of ulnar destroyed. *b*. After resection suture.

Case 19.—Gnr. L., age 19. Shell wound of left arm, with compound fracture of humerus, lower third, October, 1916.

October, 1917: Complete paralysis of all ulnar muscles below elbow with R.D., and sensory loss in ulnar area. Fibrosis of flexor muscles of forearm.

Operation, October, 1917.—Five centimetres of nerve destroyed—dense scar intervening between two bulbs (*Fig.* 363). Translation of nerve to front of elbow. Flexion of elbow. Resection. Suture. Protection with Cargile membrane.

August, 1918: Complete return of sensibility to pin-prick. Voluntary power and faradic response in flexor carpi ulnaris and flexor profundus digitorum. Hypothenar muscles very tender to pressure. No return of voluntary power in small ulnar muscles of hand.

Summary.—Recovery of flexor carpi ulnaris and flexor profundus in 10 months. Recovery of sensation. No recovery in small muscles of hand.

The first of the next two cases—both sutures of the median—is interesting, because of the fact that, after primary suture performed in France, which failed on account of suppuration of the wound, delayed suture was followed by rapid recovery.

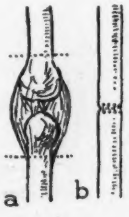

FIG. 364.—*Case* 20.

Complete section of median, with bulbs, 8 months after primary suture in wound which suppurated. *a*. Before, *b*. After operation.

Case 20.—Pte. G., age 23. Shell wound of middle of right arm, October, 1917. Note from C.C.S.: "E. and E. middle of arm, brachial artery thrombosed, tied above and below, median nerve found divided and sutured. Bipp."

December: Wounds healed.

May, 1918: Complete paralysis and R.D. in all median muscles of forearm and hand, with sensory loss in median area. No formication on percussion below level of injury.

Operation, May 25.—Scar excised, 5 cm. gap (*Fig.* 364). Flexion of elbow. Suture. Cargile membrane.

July 28: Sensibility to pin-prick recovering. Formication has progressed 260 mm. below level of suture, an average of 4 mm. per diem.

October: Further recovery of sensation. Voluntary power in flexor carpi radialis, pronator radii teres, and flexor longus pollicis. Faradic response in flexor longus pollicis.

Summary.—Considerable improvement in 5 months.

The second case demonstrates the same topography of the nerve fibres of the median in the forearm which was mentioned when describing the cases of double lateral implantation of the ulnar into the median.

FIG. 365.—*Case* 21.

Lateral neuroma of median on radial side, involving fibres to opponens pollicis and abductor brevis pollicis.

Case 21.—A.-B. S., age 19. Bullet wound of middle of left forearm, with fractured radius, January, 1918.

April: Hyperæsthesia of ring, middle, and index fingers. Brush not felt over median area of thumb. Paralysis and R.D. of opponens pollicis and abductor brevis pollicis. Diagnosis: Neuroma of median on radial side of nerve.

Operation, April.—Diagnosis confirmed (*Fig.* 365). Partial exsection and suture. Cargile membrane.

October: Weak voluntary power in abductor brevis pollicis and opponens pollicis. Incomplete R.D.

Summary.—Considerable improvement in 5 months.

The last case showing 'considerable improvement' is that of an injury to the anterior crural nerve in the groove between the psoas and iliacus muscles in the iliac fossa. Injuries to this nerve are rarely seen, and this example is of peculiar interest in that it produced a true and most intense causalgia in the cutaneous distribution of the nerve.

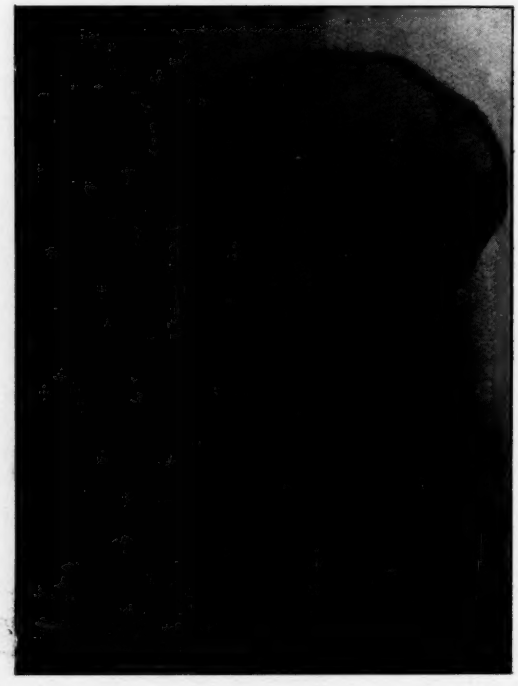

FIG. 366.—*Case* 22.

Perforating wound of left ilium, involving anterior crural.

Case 22.—Cpl. S., age 28. Through-and-through shell wound of back and abdomen, July, 1917. Foreign body removed from abdominal wall in France. Abdomen opened, through-and-through hole of small intestine 25·3 cm. from duodenojejunal junction closed. Pain in left leg.

Aug. 30: Admitted. Intense pain over front of left knee. Complete paralysis with R.D. in quadriceps extensor, with advanced wasting of muscle. Skin dry, yellow, and resembling parchment.

September: No relief. Patient states he finds life unbearable. Insomnia and loss of appetite. *X* ray shows perforating wound of left ilium (*Fig.* 366). Fragments of bone in aperture. Wound in back suppurating.

October: Excision of wound in back *en masse*. B.I.P.P. and suture. Primary union.

Operation, November.—Oblique incision, parallel to and 1·5 cm. above Poupart's ligament in its outer third, carried upwards and backwards 5 cm. beyond the anterior superior iliac spine. External oblique split and held apart with large retractors. Peritoneum pushed inwards and upwards by gauze dissection. Nerve exposed in groove between psoas and iliacus. Large lateral neuroma found, adherent to scar and muscles (*Fig.* 367). Total exsection of affected segment. Suture.

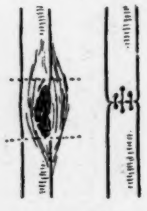

FIG. 367.—*Case* 22.

Lateral neuroma of anterior crural.

November: Immediate relief of pain.

May, 1918: Voluntary twitching in quadriceps.

July: Patient can raise heel from ground with extended knee. Thigh muscles still weak and easily fatigued. No faradic response in quadriceps.

Summary.—Considerable improvement in 8 months.

C. IMPROVED CASES.

These comprise sutures of 4 ulnar nerves, 2 median, 1 musculospiral, and 1 posterior tibial. The first and second ulnar cases exemplify what has already been said about the comparative rate of recovery in this nerve. The third is interesting in the improvement which followed resection suture in a nerve apparently ligatured in error 2 years and 5 months previously. The only comment the last calls for is that a severe attack of cerebrospinal fever beginning within a week of operation did not hinder regeneration.

Case 23.—Pte. M., age 22. Small shrapnel wound of right upper arm 7·5 cm. above internal epicondyle, September, 1916.

December: Complete paralysis of all ulnar muscles below elbow with R.D., and corresponding sensory loss.

Operation, Dec.—Condition as in *Fig.* 368. Translation of nerve to front of elbow. Flexion of elbow. Resection. Suture. Cargile membrane.

March, 1917: Recovering protopathic sensation.

April 24: Further recovery of sensation. Formication has progressed 150 mm. below suture line, an average spread of 1·2 mm. per diem.

May 29: Voluntary power in flexor carpi ulnaris and ulnar half of flexor profundus digitorum.

Summary.—Improvement in 4 months.

FIG. 368.—*Case* 23.

Complete division of ulnar. *a*. Before, *b*. After resection suture.

Case 24.—Pens. B. Wounded in middle of upper arm, September, 1915. Wounds suppurated.

Operation, June, 1916.—Ulnar completely divided, with two end bulbs. Resection. Suture.

January, 1917: Recovery of sensibility to pin-prick over ulnar side of ring and radial side of little finger. Voluntary power in flexor carpi ulnaris and flexor profundus digitorum. Bad degree of claw hand.

Summary.—Recovery of voluntary power in flexor carpi ulnaris and flexor profundus in 7 months.

FIG. 369.—*Case* 25.

Complete division of ulnar, possibly due to accidental ligature of nerve. *a*. Before, *b*. After resection suture.

Case 25.—Dvr. S., age 21. Cut his arm in August, 1914. No disability of the hand resulted. Hæmorrhage forty-eight hours after accident. Ligature passed on needle, without anæsthetic, and tied. This was immediately followed by pain and numbness in little finger.

December, 1916: Voluntary power in flexor carpi ulnaris and flexor profundus digitorum. Claw hand. Paralysis with R.D. of all small ulnar muscles, with corresponding sensory loss.

Operation, December.—Condition as in *Fig.* 369, suggesting that a ligature had been tied tightly round the nerve. Dislocation of nerve to front of elbow. Resection. Suture. Cargile membrane.

March, 1917: Recovery of sensibility to pin-prick over ulnar side of ring finger and radial side of little finger. Formication has progressed 80 mm. below suture line in 88 days, an average of 0·9 mm. per diem.

Summary.—Resection suture 2 years and 5 months after injury. Improvement after 3 months.

Case 26.—Pte. K., age 24. Bullet wound of right forearm, July, 1916.

Operation, April, 1917.—Complete section of ulnar (*Fig.* 370). Resection. Suture. Cargile membrane.

April 16: Onset of severe attack of cerebrospinal meningitis.

May 25: Pin-prick felt over radial border of little finger. Paralysis and R.D. in all muscles of hand. Formication 50 mm. below level of suture, an average of 1·1 mm. per diem.

Summary.—Improvement in 1 month.

FIG. 370.—*Case* 26.

Complete division of ulnar, with large bulb on peripheral segment. *a*. Before, *b*. After resection suture.

Of the two median cases, one was a complete section in the forearm below the origin of the anterior interosseous, which improved within 4 months of suture and which calls for no further comment. The other not only exemplifies the internal topography of the median fibres in the forearm, but throws light on the fate of Cargile membrane.

Case 27.—Sgt. K., age 32. Shrapnel wounds of legs and forearms, October, 1916. Severe pain in middle finger, and to a less degree in index finger, of right hand. Paralysis with R.D. in opponens pollicis and abductor brevis pollicis. Pin-prick abolished on palmar surface of thumb.

Operation, Oct. 28.—Median exposed 7·5 cm. above wrist. Condition as in *Fig.* 371. Partial exsection and suture. Cargile membrane.

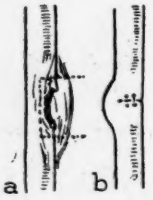

FIG. 371.—*Case* 27.

Lateral notch on radial side of median nerve. *a.* Before, *b.* After partial resection and suture.

January, 1917: Aneurysm of radial artery at right wrist developed.

Operation, January.—Artery tied above and below, and sac excised. Site of previous operation explored. Nerve still wrapped in Cargile membrane. Membrane lay snugly round the nerve, was grey in colour, and had lost its polished appearance. It felt soft and pliable instead of crinkly and brittle. Considerable young fibrous tissue had formed round the membrane, but nerve and membrane lay free from adhesions.

The Cargile membrane for three months had fulfilled the purpose of preventing adhesions to the nerve, ingrowth of scar tissue between the opposing raw surfaces of the partially divided nerve, and the escape of young nerve fibres.

Summary.—Cargile membrane still present after 3 months. Nerve free from adhesions.

The musculospiral case does not require comment.

Case 28.—Sgt. E., age 23. Shell wound of right arm 10 cm. above elbow, July, 1917. Paralysis of musculospiral muscles, with R.D.

Operation, January, 1918.—Neuroma with lateral notch (*Fig.* 372). Partial exsection and suture.

March: Formication 50 mm. below level of suture. No muscular recovery.

Summary.—Improvement in 2 months.

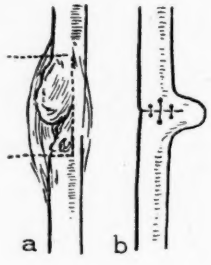

FIG. 372.—*Case* 28.

Lateral notch of musculospiral. *a.* Before, *b.* After partial exsection and suture.

The posterior tibial case throws light on the causation of pain in incomplete injuries of nerves. An artery firmly bound by scar to a nerve on which is a small lateral neuroma is a condition associated with pain. This fact has often been noted.

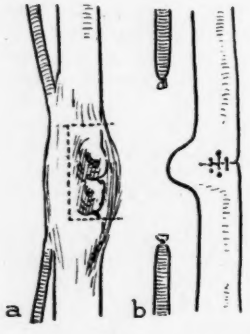

FIG. 373.—*Case* 29.

Lateral notch of posterior tibial. Artery bound down to nerve with scar tissue. *a.* Before, *b.* After excision of portion of artery and partial exsection and suture of nerve.

Case 29.—Pte. P., age 21. Through-and-through bullet wound of upper third of left leg, April, 1917.

May: Wounds healed. Severe pain in sole of foot. No loss of movements.

Operation, May 26.—Nerve embedded in scar tissue. Posterior tibial artery firmly bound to nerve by scar (*Fig.* 373). Artery tied above and below, and intervening portion excised. Partial exsection and suture of nerve.

July 21: Tenderness of sole of foot cured. No loss of movements. Formication 110 mm. below level of lesion—an average spread of 2 mm. per diem.

Summary.—Artery bound to nerve by scar associated with pain, relieved by operation.

D. NO-RESULT CASES.

These number 14. The length of time since operation varies from 24 months to 1 month. In the table of results there is no case of improvement at a date after operation later than 7 months. This lapse of time has therefore been arbitrarily chosen as a means of drawing a dividing line between cases which are actual failures and those which are only doubtful. Divided in this way, there are 5 failures and 9 doubtful cases.

i. **Failures.**—The study of these 5 cases throws interesting light on at least two causes of failure, and two of them provide food for reflection on the normal processes of regeneration, and on the best way of helping nature to carry these out.

The first case, one of ulnar destruction in the upper arm, illustrates the importance of a preliminary toilet by excising large adherent scars, either before or at the same time as the operation on the nerve, and of obtaining a covering of healthy skin either by some plastic procedure or by a preliminary pedicle graft.

Case 30.—Lieut. H., age 26. Large lacerated wound extending from axilla to elbow, and involving half the circumference of the arm on its postero-internal aspect, May, 1917.

July: Wound healed.

September: Complete paralysis with R.D. of all median and ulnar muscles below elbow, with corresponding sensory loss. Fingers very stiff. Later: Great pain in median sensory area. Flexor carpi radialis and flexor sublimis digitorum act feebly. Still complete paralysis and R.D. in ulnar.

Operation, Sept. 26.—Long incision from axilla to elbow just in front of scar. Scar raised from median and ulnar nerves. Neuroma of median. Neurolysis and capsulectomy. Ulnar found destroyed for 7·5 cm. Translation of nerve to front of elbow. Resection. Suture. Gap 10 cm. Flexion of elbow. Cargile membrane.

Oct. 6: Old scar broke down. Primary union of operation wound.

October: Cargile membrane pulled out of hole in scar, which refused to heal.

November: Wound healed.

May, 1918: Nearly complete recovery in median. No sign of recovery in ulnar.

Summary.—No recovery in ulnar 8 months after suture. Scar broke down over Cargile membrane. Recovery in median.

FIG. 374.—*Case* 31.

[Compound fracture of humerus which complicated complete section of median.

In the following case, one of median and internal cutaneous division, there were several unfavourable conditions, all of which may have influenced the result.

Case 31.—Pte. P., age 18. Shrapnel wounds of right arm, with compound fracture of humerus 15 cm. above elbow, June, 1916 (*Fig.* 374). Complete paralysis of all muscles below the elbow, with sensory loss in median, ulnar, and internal cutaneous areas.

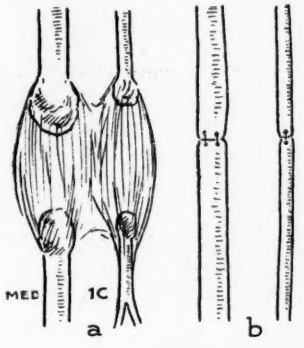

FIG. 375.—*Case* 31.

Complete section of median and internal cutaneous. *a*. Before, *b*. After resection suture.

October: The musculospiral and ulnar nerves have recovered. Complete paralysis with R.D. of median muscles. Sensory loss in median and internal cutaneous areas.

October, 1916, to May, 1917: Several sequestrotomies and removals of foreign bodies. Nerve condition unaltered. Hand cold and cyanosed. Radial pulse not palpable.

Operation, June, 1917.—Median and internal cutaneous found divided (*Fig.* 375). Resection. Suture. Cargile membrane.

January, 1918: No sign of recovery in median or internal cutaneous. No formication at level of suture.

Summary.—Obliteration of brachial artery. Suture of divided median and internal cutaneous 12 months after division. No recovery in 8 months.

The last two cases of failure are both sutures of the external division of the sciatic before it had left the sciatic trunk. In the one there was a deep lateral notch, in the other a hard neuroma.

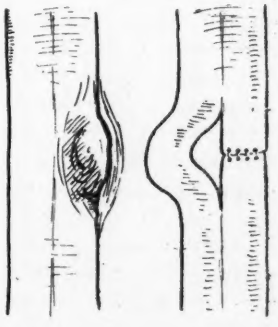

FIG. 376.—*Case* 32.

Lateral neuroma of external popliteal. Before and after exsection suture.

Case 32.—Pens. S., age 20. Shrapnel wound of right buttock, March 4, 1917. Foot dropped instantly.

October: Paralysis of external popliteal muscles with R.D., and sensory loss in external popliteal area. Formication at level of lesion.

Operation, October.—Neuroma of external division of sciatic at level of fold of buttock, adherent to scar and muscles (*Fig.* 376). Total exsection. Suture. Cargile membrane.

August, 1918: No recovery. Tinel's sign absent.

Summary.—No recovery 10 months after resection suture.

Case 33.—Pens. N., age 23. Bullet wound of right buttock, November, 1915. Drop foot. March, 1917: Complete paralysis with R.D. in external popliteal muscles, and corresponding sensory loss. Tinel's sign at level of lesion.

Operation, March.—External division of sciatic practically divided by deep lateral notch at level of fold of buttock, with well-defined bulb of upper segment (*Fig.* 377 *a*, *b*). Resection. Suture. Cargile membrane.

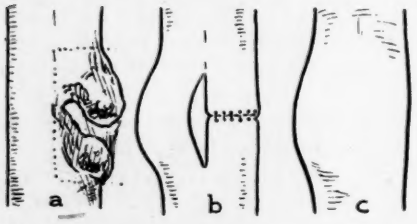

FIG. 377.—*Case* 33.

a. Lateral notch in external sciatic. *b*. After resection suture. *c*. Nineteen months later.

October, 1918: No sign of recovery. Tinel's sign absent.

Operation, October.—Nerve exposed. Considerable perineural scar tissue. Cargile membrane completely disappeared. No bleeding from surface of nerve on freeing from scar. Line of external division of sciatic continuous. No spindle or bulbs, and no trace of suture line. Bulge of internal sciatic still visible (*Fig.* 377 *c*). Incision closed. Whole of external division looked slightly yellow, and felt distinctly less firm than internal division. No conduction of faradic current.

Summary.—No recovery 19 months after suture. Exploration revealed apparently normal nerve with some perineural scar tissue. Disappearance of Cargile membrane.

These two cases are of considerable interest, the absence of recovery apparently depending on a cessation of growth of the axis cylinders from the central segment. In the first case, no special reason for this inability on the part of the nerve cells to reproduce axis cylinders suggests itself. In the second case, sixteen months elapsed between the dates of the wound and operation, and this length of time since injury might be held accountable. It is well known, however, that delayed suture has been successfully performed at a much later date than this.

Another possibility requires consideration. Each axis cylinder is, on the neurone theory, the process of a single nerve cell. When an axis cylinder is cut across, the distal portion degenerates, and there is also at first a retrograde degeneration of the central portion. The central portion then begins to regenerate by the formation of branching tendrils from the adjacent nodes two or three distant centrally from the cut (Ranvier, quoted by Cone[10]). Cone, in the article referred to, describing these regenerating cell processes, says, "They are varicose, bulbed at the end, frequently branch . . ." Each nerve cell, then, when its axis cylinder process has to regenerate, produces a number of feelers or tendrils which grow downwards, attracted may be by the sheaths of Schwann. Where there was one cell process there are now many, a kind of dendritic formation. What happens to these dendritic processes? Is it not reasonable to suppose that this is Nature's way of increasing the chance of at least one taking the correct path and becoming ultimately the adult axis cylinder in the distal segment? The fate of those which err on the way is unknown, but it is conceivable that they may ultimately shrivel or be withdrawn into the cell. In any case, the power of reproducing an axis cylinder, on the neurone theory, resides in a single cell, and means a considerable expenditure of regenerative vitality. The question which must be asked is: How often will a nerve cell repeat this regeneration of its axis-cylinder process? The frequent recoveries after resection sutures tell us that, in most individuals, nerve cells will repeat this process at least twice; but it is as unreasonable to suppose that it can be repeated an indefinite number of times as it is to suppose that an amœba might have its pseudopodia cut off an indefinite number of times and continue to live. Recovery after delayed suture, even in the absence of suppuration, is always slower and less complete than recovery after a primary suture. This is well established. Does this not indicate a regeneration fatigue on the part of the nerve cell, and may it not be that in certain individuals the nerve cells are only capable of this function once? This is the only explanation which suggests itself to the writer to account for the facts of the last case described. In this the nerve had apparently united perfectly; but the absence of all signs of recovery, including conduction of the electric current and Tinel's sign, proves that no axis cylinders had grown down from the central end; while the absence of any bulb or thickening above the suture

line, together with the absence of Tinel's sign at this level, suggests failure of the axis cylinders to reproduce themselves.

ii. **Doubtful Cases.**—The doubtful cases are 7 ulnar and 2 median sutures. One ulnar case was invalided five months after suture, and thereafter lost sight of. Another was transferred to Dartford and invalided to Australia after one month. A third was lost sight of two months after operation. The remaining 4 ulnar and 2 median cases concern four individuals still under observation, two of whom had a combined median and ulnar injury. Their case histories follow.

The first of them furnishes an example of an unusual nerve supply to the flexor longus pollicis, which retained voluntary power and faradic response though the median was completely divided in the lower third of the arm. Compensatory movements of flexion of wrist and fingers through the unparalyzed extensors were exceptionally developed.

Case 34.*—Pte. R., age 21. Bullet wound of lower third of right arm, August, 1917. Brachial artery divided. Complete median and ulnar paralysis.

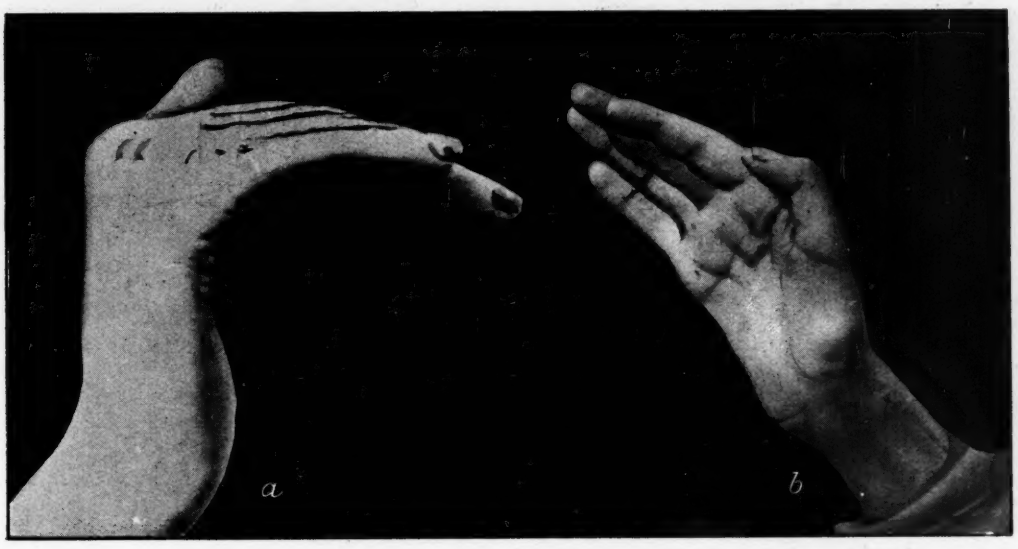

FIG. 378. *Case* 34. *a*. Shows flexion of finger in complete median and ulnar paralysis. *b*. Shows retention of voluntary power in flexor longus pollicis, though there was complete section of the median and ulnar in lower third of arm

November: Wound healed.

June, 1918: Complete paralysis with R D. of all median and ulnar muscles below elbow, with exception of flexor longus pollicis, which retained voluntary power and faradic response (*Fig.* 378). Compensatory movements very noticeable. Flexion of wrist by extensor ossis metacarpi pollicis. Flexion of fingers by extending wrist and relaxing common extensors of fingers. Sensory loss in median, ulnar, and internal cutaneous areas. Tinel's sign at site of lesion only.

Operation, June.—Complete division of median, ulnar, and internal cutaneous nerves (*Fig* 379). Resection suture of median and ulnar. Lower end of internal cutaneous not found.

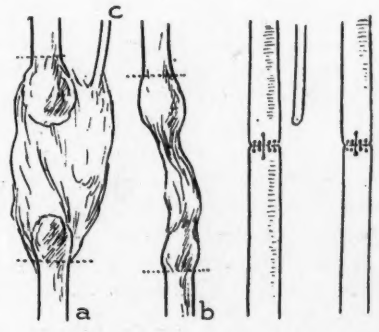

FIG. 379.—*Case* 34. Complete section of median, ulnar, and internal cutaneous in lower third of forearm. Before and after resection suture of median and ulnar; lower end of internal cutaneous not found. *a*. Median, *b*. Ulnar, *c*. Upper end of internal cutaneous.

July: No change.

Summary.—Doubtful result. Case illustrates compensatory movements of unparalyzed muscles, and abnormal nerve-supply to flexor longus pollicis.

The next case, of similar type, deserves recording as an example of the spontaneous union of the upper segment of the median with the lower segment of the ulnar.

Case 35*.—Lieut. G. Bullet wound of right shoulder, entrance outer side, bullet passing across axilla and being retained in chest, August, 1917.

January, 1918: Wounds healed.

June: Complete paralysis with R.D. of all muscles below elbow supplied by median and ulnar, and corresponding sensory loss. Compensatory movements of extensors well developed. Tinel's sign in ulnar nerve at bend of elbow.

Operation, June.—Both nerves completely divided, but upper segment of median partially united to lower end of ulnar (*Fig.* 380). Resection. Suture.

July: No change.

Summary.—Doubtful result. Union of upper segment of median with lower segment of ulnar.

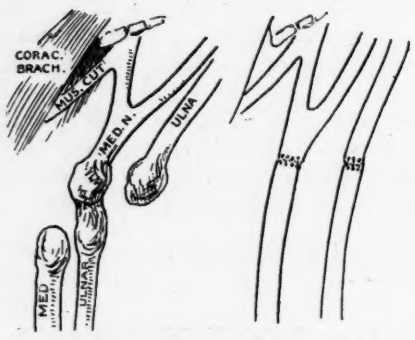

FIG. 380.—*Case* 35.

Complete section of ulnar and median with vicious union of upper segment of median with lower segment of ulnar.

The succeeding story relates an anatomical anomaly.

Case 36.*—Pte. K., age 42. Shrapnel wound of left arm above epicondyle, March, 1918.

July: Wound healed. Scar adherent to bone and nerve in epitrochlear groove. Formication at level of injury. Voluntary power and faradic response in flexor carpi ulnaris and first dorsal interosseous. Remaining ulnar muscles paralyzed, with R.D. Sensory loss confined to little finger and ulnar border of hand.

Operation, Aug.—Ulnar completely destroyed for 3·6 cm. above elbow, with bulbs. Just above upper bulb a branch from nerve was found passing in front of epicondyle (*Fig.* 381). Direct faradic stimulation of branch produced contraction of flexor carpi ulnaris.

September: No change.

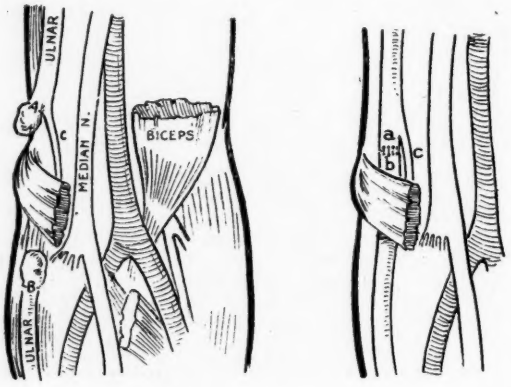

FIG. 381.—*Case* 36.

Complete division of ulnar in the region of elbow, showing abnormal branch *c*, passing in front of epicondyle.

Summary.—Complete section of ulnar behind epicondyle. Branch to flexor carpi ulnaris passing in front of epicondyle. Nerve supply to first dorsal interosseous probably from median.

The fourth doubtful case requires no comment.

Case 37.*—Rfm. F., age 31. Shell wound of middle of right forearm, August, 1917.

January, 1918: Wounds healed.

April: Complete paralysis with R.D. of small ulnar muscles of hand with clawing, and sensory loss of ulnar area.

Operation, April.—Complete section. Resection. Suture.

May: No change.

3. NEUROLYSES.

Tinel[11] thus describes a neurolysis or liberation: "La libération consiste essentiellement dans la dissection du nerf et dans l'ablation des causes de compression, cal osseux, gangre fibreuse, ou bride cicatricielle." He lays down the dictum, "Pour tous les cas, douteux, il faut se rappeler qu'une bonne et franche suture vaut beaucoup mieux qu'une mauvaise libération." Delagenière, quoting Tinel's opinion says, "It is

* Since working out the statistical part of this paper, *Cases* 34 to 37 show definite signs of improvement.

very difficult to form an opinion of the value of nerve liberations. We have done relatively few, because it has seemed to us that they do not generally give better results than abstention."

A discussion on the value of neurolysis must begin with a succinct statement of the

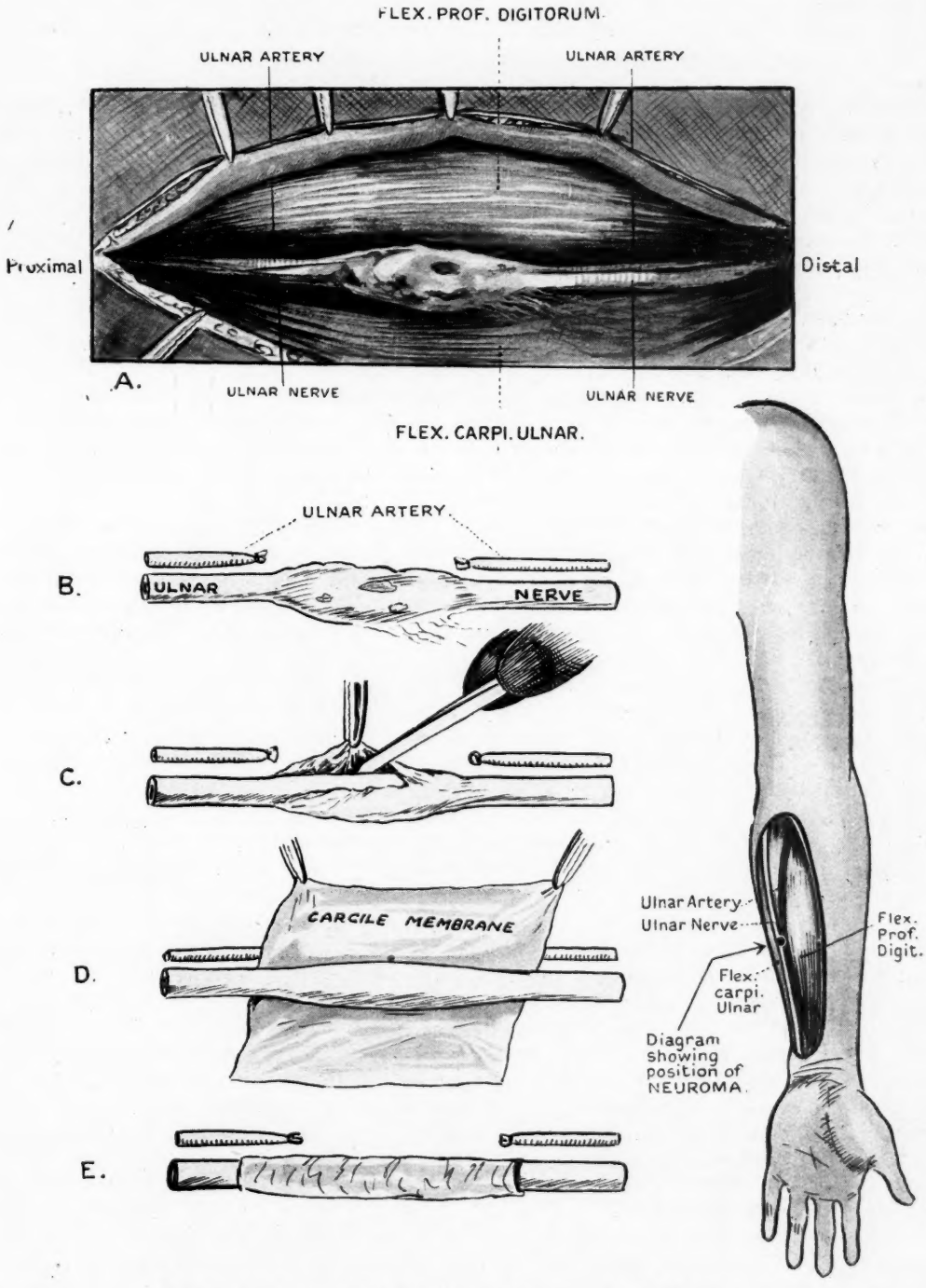

FIG. 382. Details of neurolysis capsulectomy, drawn from an actual case.

exact details of the operation performed, must continue with a clear understanding of the type of case in which it is used and of the results which it is hoped to obtain, and must be settled by an appeal to actual case-histories, comparing the results with those following other surgical procedures and those following abstention.

The operation performed consists in dissecting out the nerve, and removing all causes of compression such as bony callus, fibrous tissue, and adhesions. The thickened portion of the sheath of the nerve must also be removed. This latter procedure is hereafter called a 'capsulectomy.' The details are shown in *Fig.* 382, drawn from an actual operation.

After a capsulectomy, the next and possibly the most important step is to protect the delicate nerve spindle which has been stripped of its sheath, and to prevent its compression by fresh adhesions or the contraction of new scar tissue. The natural bed for a nerve is the intramuscular space, and in every case this space is the ideal bed, and should be sought after. In the forearm, where there are many contiguous muscle bellies, and in the upper arm, where the space between the biceps and brachialis anticus is available, the plan can usually be adopted of laying the nerve in healthy tissue between muscles.

In some situations—as, for example, the musculospiral in the groove—the attainment of a natural bed for the nerve is impossible. The writer in these cases has generally employed a covering of Cargile membrane, around which the adjacent muscles are neatly stitched so as to prevent it becoming unrolled. Cargile membrane is sold in different thicknesses, and it is a matter of some importance to choose the finer varieties, in view of Souttar's[12] observation on the exploration of old nerve sutures protected in this way, that he found the membrane lying in the tissues as a loose foreign body. When used in the way indicated, no harm has been observed to follow its employment. The writer has explored four nerves protected with Cargile membrane, at intervals of 3, 4, 7, and 19 months (*Cases* 5, 7, 26, and 32). From them the conclusion is drawn that the membrane is absorbed in under six months, during which time it fulfils its purpose in protecting the nerve from compression and adhesions. Cone observes that Cargile membrane is impervious to nerves, and it may therefore be also expected to prevent the straying of nerve fibres.

The plan adopted by some workers of making a bed for the nerve by a small longitudinal incision into an adjacent muscle belly is regarded with diffidence, on account of the fact so often noticed of the tendency of cut muscles to adhere to injured nerves.

Types of Cases in which Neurolysis and Capsulectomy have been Performed.—The cases in which this operation has been performed are divided into four groups: (*a*) Those with complete physiological interruption; (*b*) Those with incomplete physiological interruption; (*c*) Those where pain has been the indication for interference, with or without complete or incomplete physiological interruption; (*d*) Those associated with aneurysms and brachial plexus injuries.

The writer believes that the reason for Tinel's remarks quoted at the beginning of this section—which have also been echoed by writers in this country—has been an unjustified expectation of what the operation is capable of doing. Neurolysis, in cases where compression by extraneural conditions is the only factor involved, is followed by an extremely rapid recovery occurring within a few days. Because these striking results have not followed the operation in other cases where other factors are involved, the operation has been too hastily abandoned in favour of resection suture. Among the unoperated cases are several examples of spontaneous regeneration occurring along the same lines as after a primary suture of a completely divided nerve. In such a case the operation of neurolysis cannot be expected to produce a cure in a few days. At most it could hasten and render such a recovery more complete. Regeneration is a slow and tedious affair after all sutures.

Realizing then that neurolysis, in some cases combined with a capsulectomy, cannot be expected to produce a rapid cure except in cases of pure extraneural compression, the following questions remain to be answered by an appeal to the series of cases in which

this operation has been performed: (1) Can a neurolysis remove the conditions which inhibit regeneration in a nerve anatomically continuous but physiologically interrupted, with degeneration in the segment below the injury? (2) Can a neurolysis hasten recovery in a nerve anatomically continuous which has been physiologically interrupted, but which is regenerating in the segment below the injury? (3) Of what value is neurolysis in cases where pain is the chief symptom to be relieved?

A. CASES OF COMPLETE PHYSIOLOGICAL DIVISION.

Out of 39 cases undergoing neurolysis, 17 were undertaken for complete physiological interruption of the nerve, without loss of anatomical continuity, but with no sign of regeneration in the segment below the injury. The results are shown in *Table VI.*

Table VI.—Neurolysis and Capsulectomy in 17 Cases of Complete Physiological Interruption.

	Recoveries	Considerable Improvement	Improvement
Number of cases	8	6	3
Average time since wound	17 months	11 months	8 months
Average time since operation	12 ,,	8 ,,	3 ,,
Longest ,, ,, ,,	24 ,,	13 ,,	3 ,,
Shortest ,, ,, ,,	6 ,,	1 ,,	1 ,,

i. **Recovered Cases.**—These comprise 2 ulnar, 1 musculospiral, 1 musculocutaneous, 1 posterior interosseous, 1 sciatic, 1 posterior tibial, and 1 brachial plexus injury. The brachial plexus injury, forming with others of the same nature a special group, will be described in a later section of the paper. The case histories follow.

Case 38.—Pte. F., age 24. Through-and-through wound of flexor aspect of right forearm 5 cm. above wrist, August, 1916.

September: Wounds healed.

December: Claw hand. Complete paralysis with R.D. of ulnar muscles of hand. Complete ulnar sensory loss.

Operation.—Neuroma (*Fig.* 383). Neurolysis. Capsulectomy. Cargile membrane.

November, 1917: Complete return of protopathic sensation. Voluntary power in small muscles of hand.

Summary.—Recovery in 11 months.

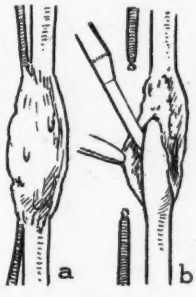

Fig. 383.—*Case* 38.

a. Spindle neuroma of ulna. *b.* Neurolysis capsulectomy.

Case 39.—Pte. P., age 20. Shell wound of lower third and middle of right arm, with compound fracture of humerus, February, 1916.

April: Wrist-drop and paralysis of musculospiral. Great pain in median area. Total paralysis of ulnar. Hand useless.

May: Fracture united. Early recovery of musculospiral. Median and ulnar condition unchanged.

October: Wound healed. Continued improvement in musculospiral. Median and ulnar paralysis.

January, 1917: Musculospiral recovered. Hyperalgesia in median. Anæsthesia in ulnar. Median muscles have voluntary power, but are very wasted. Ulnar muscles have no voluntary power and complete R.D.

Operation, Jan. 16.—Incision through very wide scar above elbow. Ulnar thickened, with very hard neuroma. Median involved in dense scar. Neurolysis and capsulectomy of median and ulnar. Cargile membrane. Wound healed by primary union.

March: Scar broke down. Cargile membrane expelled.

April: Scar sound.

Aug. 24: Steady improvement. Formication at level 5 cm. above wrist—250 mm. in 220 days.

January, 1918: Voluntary power in all muscles of median and ulnar. Complete return of sensibility to pin-prick. Hand still tender.

Summary.—Recovery in 12 months. Cargile membrane expelled.

The next case, that of the musculospiral, illustrates a condition noticed by Renfrew White,[13] where a division of this nerve may produce an area of sensory loss on the dorsum of the hand in which protopathic loss overlaps and extends beyond the area of epicritic loss.

Case 40.—Pte. S., age 20. Shell wound of lower third of right arm, with fracture of humerus, January, 1917.

April: Wound healed. Fracture united.

July: Complete paralysis and R.D. in musculospiral below elbow. Sensation as in *Fig.* 384.

FIG. 384.—*Case* 40. Extent of loss of sensation to *a*. Pin-prick, *b*. Cotton-wool.

Operation, July.—Hard neuroma, involving 7·5 cm. of nerve, freed from scar (*Fig.* 385). No conduction of faradism above or below injury. Resection considered necessary, but abandoned on account of the wide gap which would have been left. Capsulectomy. New path for nerve in brachialis anticus. Cargile membrane.

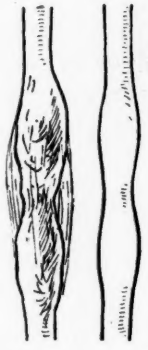

FIG. 385.—*Case* 40. Neuroma, with complete physiological interruption, of musculospiral. Before and after neurolysis capsulectomy.

January, 1918: Complete return of sensation both to pin-prick and brush. Voluntary flicker in extensors of wrist.

July: Complete recovery in all muscles.

Summary.—Recovery after 12 months.

Case 41.—Pte. B., age 25. Bullet wound of left shoulder, January, 1917.

April: Complete musculocutaneous paralysis, with R.D. of biceps, coracobrachialis, and brachialis anticus.

Operation.—Nerve freed from scar. Capsulectomy of neuroma. Free flap of fat and fascia wrapped round nerve.

October: Upper arm still smaller than right. Voluntary power and faradic response in biceps. Voluntary power in brachialis anticus.

Summary.—Recovery in six months.

Case 42.—Pte. T., age 22. Bullet wound of right forearm, with compound fracture of neck of radius and injury to posterior interosseous, August, 1915.

November: Complete paralysis with R.D. of wrist, finger, and thumb extensors.

Operation, November.—Nerve freed from callus. Neuroma on nerve just above level of division into muscular branches.

February, 1916: No recovery. Invalided.

March, 1918 (by examination): Complete recovery of extensors of wrist and fingers. No faradic response, but brisk galvanic, without polar changes.

Summary.—Recovery within 2 years.

Case 43.—Pte. T., age 21. Bullet wound of left buttock, Sept. 25, 1916.

November: Wound healed.

December: Complete paralysis of all muscles below knee with R.D., and sensory loss in areas of internal and external popliteal.

Operation, December.—Nerve freed from dense scar and wrapped in Cargile membrane. No apparent injury to nerve.

January, 1917: Voluntary flicker in tibialis anticus. No other change. Invalided.

December (extract from letter): "My leg has made good progress—the muscles have developed and are nearly normal again, the calf muscle is also making rapid progress. I have a fair amount of movement in my foot, but there is still a little drop. I manage to get about without my sticks or the splint, and am able to attend my work, which is engineering."

Summary.—Recovery in 11 months.

Case 44.—Pte. B., age 26. Shell wound of right leg, lower third, July 15, 1916.

December: Anæsthesia of sole of foot and paralysis of small foot muscles, with R.D. Percussion over scar causes pins-and-needles in foot.

Operation, December.—Neuroma of nerve freed from scar. Capsulectomy.
May, 1917: Sensation recovering.
August: Faradic response from small muscles of foot. Sensation recovered.
Summary.—Recovery in 9 months.

ii. **Considerably Improved Cases.**—This group is concerned with 2 median, 1 ulnar, 1 musculospiral, 1 sciatic, and 1 brachial plexus injury. With the exception of the brachial plexus lesion, the cases are given below.

Case 45.—Pte. S., age 34. Through-and-through bullet wound of front of left elbow, with fracture of neck of radius, April, 1917.
July: Complete paralysis of all median muscles with R.D., and complete sensory loss.
Operation, July 21.—Nerve and its muscular branches freed with great difficulty from dense scar. Superficial head of pronator radii teres divided. Large hard neuroma. Capsulectomy. New intermuscular path provided.
October: Hand cyanotic. Some recovery of pin-prick sensation.
April, 1918: Voluntary power in flexors. None in opponens pollicis. Pin-prick everywhere felt.
August: Voluntary power in all median muscles, including opponens pollicis and abductor brevis pollicis, but fingers still painful and stiff. Hand still cyanotic.
Summary.—Considerable improvement in 13 months.

Case 46.—Lieut. H., age 30. (See *Case* 29.)

Case 47.—A.-B. C., age 21. Through-and-through bullet wound of lower third of upper arm, October, 1917.
April, 1918: Paralysis of ulnar muscles below elbow with R.D., and complete sensory loss.
Operation, May 9.—Neuroma of ulnar where nerve passes through internal intermuscular septum. No faradic conduction. Neurolysis. Capsulectomy. New intermuscular bed provided.
Aug. 9: Tinel's sign. Average spread, 1·5 mm. per diem. Voluntary power in flexor carpi ulnaris and whole of flexor profundus digitorum. Clawing of little and ring fingers increased. Recovery of protopathic sensation.
Summary. — Considerable improvement in 5 months.

Case 48.—C.-S.-M. H., age 28. Bullet wound of upper third of left arm, with compound fracture of humerus, March, 1918.
July: Complete paralysis of all musculospiral muscles, with R.D.
Operation, July.—Very hard spindle in course of nerve involved in callus (*Fig.* 386). Faint faradic response in radial extensors to strong current. None in other muscles. Neurolysis. Capsulectomy.
September: Voluntary power in radial extensors. Still R.D. of all musculospiral muscles.
October: Weak voluntary power in common extensors. Good voluntary power in radial and thumb extensors. Still no faradic response.
Summary. — Considerable improvement in 4 months.

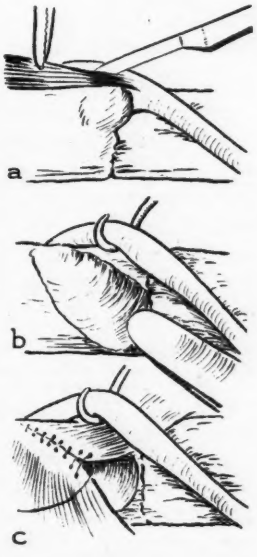

FIG. 386.—*Case* 48.
a. Neuroma of musculospiral involved in fracture. *b*. Nerve freed. New groove cut in bone. *c*. Groove lined with muscle forming bed for nerve.

Case 49.—Pte. S., age 28. Shrapnel wound of left buttock, July, 1917. Foot drop. Severe pain in left foot.
August: Complete paralysis with R.D. of external popliteal muscles, and corresponding sensory loss. Severe pain and tenderness of sole of foot.
Operation, August.—Gluteus maximus split, pyriformis retracted upwards. Shrapnel ball removed from hole in ilium. Several small bone fragments removed from nerve. Neuroma of outer side of nerve. Capsulectomy. Pedunculated flap of fat inserted between bone and nerve.
October: Less pain in foot.
February, 1918: Sensation recovered except on dorsum of three outer toes.
June: Weak voluntary power in all muscles below knee. Faradic response present.
Summary.—Considerable improvement in 11 months.

iii. Improved Cases.—These are 1 median, 1 sciatic, and 1 peroneal injury.

Case 50.—Pte. P., age 31. Through-and-through wound of upper third of right forearm, January, 1917. Six days after wound severe secondary hæmorrhage. Proximal ligature of brachial.

June: Severe ischæmic contracture of flexors. Complete sensory loss in median area, with paralysis of opponens pollicis and abductor brevis pollicis, with R.D.
Operation.—Hard neuroma freed from scar tissue. Capsulectomy. Cargile membrane.
September: Partial recovery of protopathic sensation.
Summary.—Improvement in 3 months.

The sciatic case is an interesting example of the bad result afforded by a protective sleeve of fascia lata. This case was under the care of Major Guilding, who performed three operations on the case, and kindly allowed the writer to assist him at the third.

Case 51.—Pte. M., age 20. Bullet wound of middle of right thigh, July, 1916.
September: Drop foot. Complete paralysis of external popliteal, with sensory loss.
First Operation.—Nerve simply liberated from scar tissue.
November: No recovery.
Second Operation.—Nerve wrapped in sleeve of fascia lata.
December: Paralysis of calf muscles, with sensory loss in sole of foot, gradually supervened.
February, 1917: No change.
Third Operation.—A spindle-shaped neuroma, 7·5 cm. long, of whole sciatic trunk, involved in dense scar and adherent to surrounding muscles, was exposed and freed. The fascia lata was found to be incorporated with the sheath of the nerve, forming a dense thick capsule. One portion of the fascia retained its shiny surface, and was tightly constricting the internal division of the nerve. After a capsulectomy had been done, the surface of the spindle was covered with small bleeding spots where there had been an ingrowth of small blood-vessels from the surrounding adhesions. Bleeding checked with 1–1000 adrenalin. Cargile membrane.
June: Recovery of sensation in sole of foot. Voluntary power in calf muscles and peronei.
Summary.—Simple neurolysis gave no result in 3 months. Second neurolysis and protection with free sleeve of fascia lata was followed by an aggravation of the symptoms. Third neurolysis combined with capsulectomy and Cargile-membrane protection gave improvement in 4 months.

This case raises two questions: (1) What is the cause of the undoubted tendency of cut muscle to adhere to an injured nerve? (2) Why does a fascial sleeve afford no protection? The answer is given in Cone's researches, where he found that nerves grow in both fascia lata and muscle, and better in the former. After a suture, when the sheath has been properly approximated, a fascial sleeve may possibly protect a nerve from pressure of scar. That it may do no harm is seen in *Case* 9. In lacerated nerves where the sheath is torn, the young nerves stray, grow through the fascia into the muscles, and form a solid growth of nerve, muscle, and fibrous tissue, so that as a protection after a capsulectomy it is contra-indicated.

Case 52.—Lieut. F., age 19. Aeroplane accident, January, 1918. Fracture of right femur and left tibia. Left foot-drop. *X* ray showed external tuberosity of left tibia completely split off.
June: Complete paralysis with R.D. of external popliteal muscles, with complete sensory loss.
Operation.—Nerve found adherent to head of fibula, with flattened neuroma in its course. Neurolysis. Capsulectomy. New intermuscular path made for nerve.
July: Tinel's sign 30 mm. below level of injury.
Summary.—Improvement in 1 month.

The remaining 22 operations of neurolysis were performed either for incomplete physio'ogical divisions which were not recovering satisfactorily, or for the relief of pain (including cases associated with aneurysms and brachial plexus injuries). The tabulated results are shown in *Table VII.*

Table VII.—22 Cases of Neurolysis for Incomplete Physiological Division or for Relief of Pain.

Recovery	Considerable Improvement	Improvement
14	6	2

B. CASES OF INCOMPLETE PHYSIOLOGICAL DIVISION.

Of a group of 4 incomplete divisions or incomplete recoveries (one involving two nerves), the first is yet another example of a neurolysis capsulectomy. The second and third illustrate rapid improvement in nearly-recovered cases from a simple freeing, showing that the mobility of the nerve is of great importance to the completeness of a recovery. This suggests that massage and other means directed towards mobilization of the nerve at the level of a suture should be part of the post-operative treatment. The fourth—an early case in the series —is an example of a pithiatic condition (unrecognized at the time) combined with an organic lesion.

Case 53.—Sgt. W., age 27. Bullet wound of right forearm, May, 1915.

May, 1916: Admitted under writer. Weak voluntary power in opponens pollicis. Sensation normal on ring and middle finger. Pin-prick not felt over index finger and thumb.

Operation.—Nerve freed from scar tissue and adherent muscle. Spindle-shaped neuroma 2·5 cm. long in course of nerve. Capsulectomy. Cargile membrane.

Aug. 16: Good opposition of thumb. Recovery of protopathic sensation.

Patient returned to the army and obtained a commission.

October, 1918 (by examination): Hand perfect except compass test over palmar surface of index finger.

Summary.—Recovered. Compass test defective after 3 years.

Case 54.—Pte. W. Bullet wound of middle of right upper arm, June, 1916. Weakness in opponens pollicis, with blunting of sensation in median area.

Operation, July: Simple neurolysis of soft neuroma. New intermuscular bed made for nerve.

October: Recovered. Discharged to duty.

Case 55.—Pens. C. Through-and-through bullet wound of left forearm, May, 1915.

March, 1916: Admitted for inability to flex index and middle fingers. Hyperæsthesia of median nerve. Skin thin and glossy. Nails recurved. Pin-prick felt everywhere. Brush sensation patchy.

Operation.—Large soft neuroma simply freed from adhesions to scar and muscles.

Two days later, index and middle fingers could be flexed.

October, 1916: Recovered. Working as postal clerk.

Case 56.—Pens. R., age 33. Bullet wound of lower third of right arm, March, 1915.

October, 1916: Admitted. Stated that he had been unable to flex fingers or oppose thumb for six months after injury. Pithiatic condition. Nails recurved. Skin pink and sweating. No muscular wasting or paralysis, but unable to flex fingers. Coarse tremor when flexion of fingers is attempted, with synergic contraction of extensors. Sensation normal.

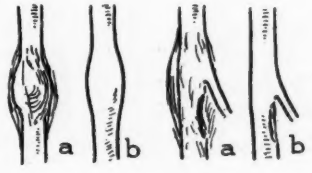

FIG. 387.—*Case* 56. *a*. Spindle neuroma of median, and small lateral notch of ulnar, associated with pithiatic condition. *b*. After neurolysis.

Operation, November.—Mulberry-like neuroma of median, and lateral neuroma of ulnar, freed from scar tissue and adherent muscles (*Fig.* 387).

March, 1917: Sweating cured. Functional tremor and inability to flex fingers unaltered.

C. PAINFUL LESIONS.

Pain has occurred in varying degrees and under various circumstances. The extreme form known as causalgia has been noted in 5 cases, affecting the median twice, and the sciatic trunk, the external popliteal, and the anterior crural once each. These cases form a distinct clinical group, and are characterized in brief by the intense paroxysmal and burning pain, by the atrophy of the limb below the lesion, by the weakness of the muscles without any definite paralysis, by the harsh dry skin and absence of perspiration, and by the peculiar mental condition which develops. Benisty[14] says, "Patients so affected are dismal, pale, and waxen. . . . They escape from noise, avoid society, and remain curled up in their beds or on a sofa in peculiar attitudes of defence." They are martyrs to insomnia, and lose their appetites. Two of the five cases threatened suicide. The group stands out in contrast with the less severe form,

in which pain, though oftentimes very severe, is not associated with any change in the patient's mentality, and in which the skin is pink, soft, and bathed in sweat.

Of three belonging to the series, two (*Cases* 15 and 22), one median and one anterior crural, have already been described; the remaining one is a particularly interesting example of an osseous formation in the sheath of the sciatic trunk, analogous to the so-called traumatic myositis ossificans. The other two cases described below, not included in the statistical tables, are given because of their intrinsic interest.

Case 57.—Pte. M., age 24. Through-and-through bullet wound of upper right thigh, October, 1916. Entrance wound left side of scrotum. Exit behind and level with tip of great trochanter.

January, 1917: Patient suffers intense burning pain, so severe at times that he is found crying. He will not leave his bed, but remains curled up under the bed-clothes. No anæsthesia. No paralysis. Much wasting of leg. Skin of foot harsh and dry.

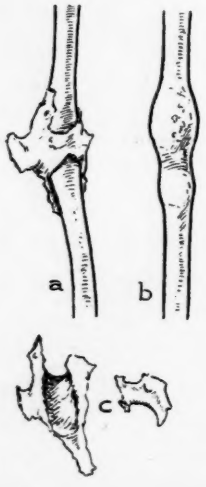

FIG. 388.—*Case* 57.

a. Neuroma of sciatic, with new bone formation in capsule. *b*. After neurolysis capsulectomy. *c*. Collar of bone removed from capsule.

Operation.—Bony collar found in sheath of sciatic trunk. The condition was that of a spindle-shaped neuroma with osseous formation in the capsule (*Fig.* 388 *a*). Neurolysis. Capsulectomy. Cargile membrane. Surface of the nerve compressed, grooved, and pitted by the bone. After removal, the pieces of bone fitted together like a jig-saw puzzle into a collar through which the nerve passed (*Fig.* 388 *c*).

A study of the position of the entrance and exit wounds suggested that the bullet grazed the tuber ischii and carried with it some osteoblasts which were deposited around a laceration of the nerve.

May: Improved. Sleeps well. *X* ray shows no recurrence.

November: Cured. Can walk about all day in boots.

December: Discharged to Command Depôt.

Summary.—New bone formation in capsule of spindle neuroma, causing pain—relieved by operation.

The next case is an example of the failure to cure the condition (causalgia) by Sicard's plan of injecting the nerve with 60 per cent alcohol—followed by immediate relief after exsection suture.

The writer views the injection of nerve trunks with some diffidence. Several cases have now been recorded in which severe trophic ulceration has been produced; and he has heard of one case in which 15 cm. of a median nerve were totally destroyed by this procedure. In addition, he has now under his observation two cases in which the internal popliteal nerve was injected with 60 per cent alcohol for pain associated with tonic spasm of the calf muscles, in which total paralysis with R.D. resulted and persisted for over six months.

Case 58.—Pte. D., age 24. Shrapnel wound of left thigh, July, 1917.

August, 1918: Shrapnel ball removed from side of knee in France.

On admission, patient was morose and silent. Complained of severe pain in left foot. Weakness but no paralysis in anterior tibial and peroneal muscles.

September: Nerve injected with 60 per cent alcohol.

October: No relief from pain.

Operation.—Small lateral neuroma of external popliteal. Affected segment exsected. Suture. Immediate relief of pain.

October, 1918: Sensibility to pin-prick recovered. Voluntary power and faradic response in anterior tibial and peroneal muscles.

Summary.—Causalgia of external popliteal. No relief after injection of 60 per cent alcohol. Cured by exsection of affected segment, with suture.

The last case is an example of causalgia resulting from a minute injury of the nerve by two tiny metal fragments some distance away from the wound.

Case 59.—Gnr. H., age 31. Shell wound of left forearm, May, 1918.

June: Very severe median causalgia of left hand.

Operation.—Scar excised. No injury to median nerve in immediate region of wound. Nerve found adherent to muscles two inches below wound. Adhesions separated. Small lateral neuroma. Two tiny metallic fragments found and removed from surface of neuroma (*Fig.* 389). Nerve injected with 60 per cent alcohol on proximal side.

October: Incomplete relief of pain.

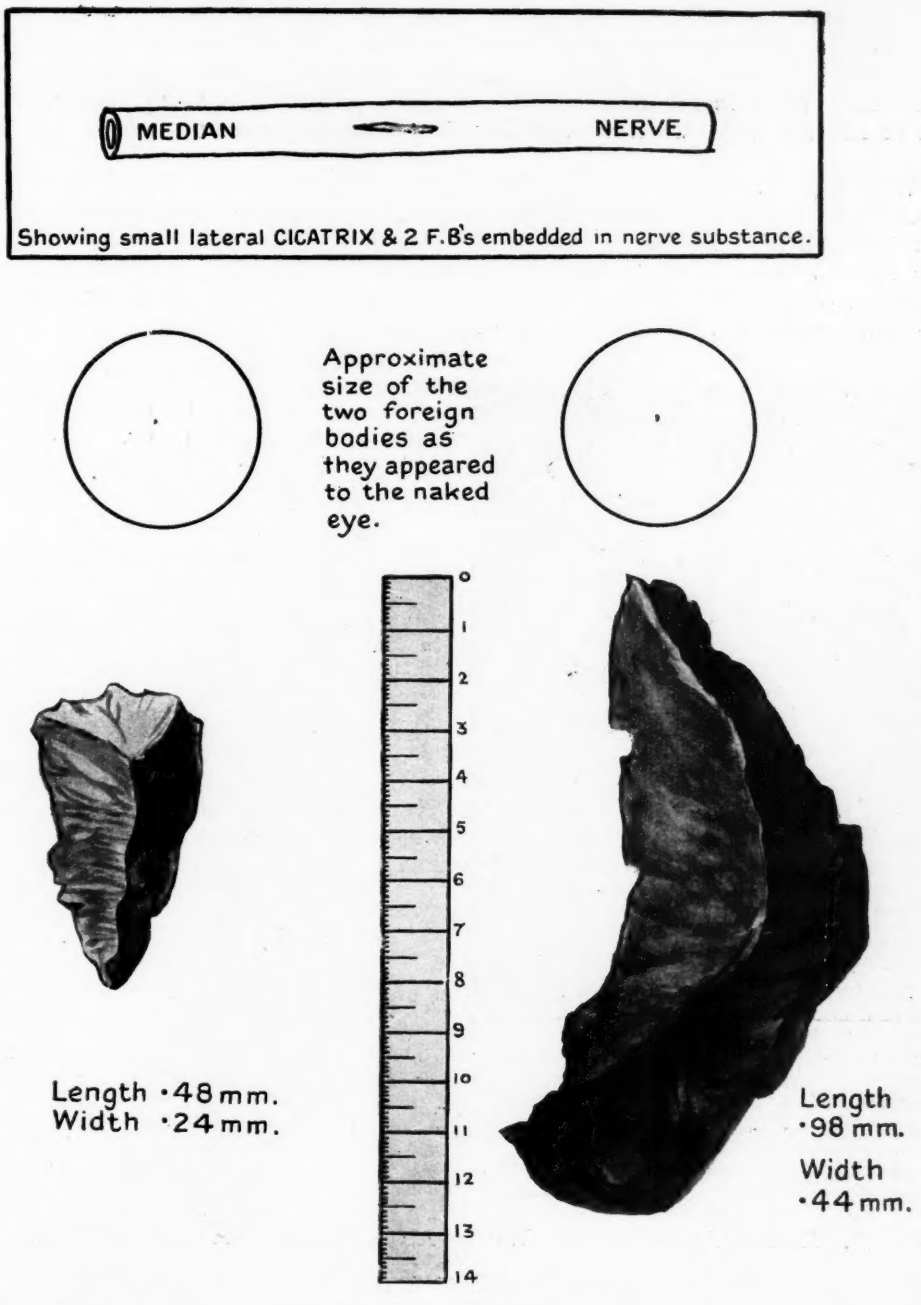

FIG. 389. *Case* 59. Tiny fragments buried in median, producing severe causalgia.

In all of the preceding cases a definite injury of a main trunk has been discovered, in four instances associated with the formation of a small lateral neuroma or lateral bulb. Of these four, in three the pain was immediately relieved by exsection of the affected segment. Why is it that this type of lesion produces a causalgia in some, pain of moderate severity in others, and no pain at all in the remainder? Marinesco and Corner[15] have explained the pain in amputation neuromata by the irritation of an infective inflammation. Possibly the answer to the question is to be found in the presence or absence of inflammation; or it may be that the inflammatory reaction to different groups of organisms provides the true solution. In this connection a study of the bacterial flora of infected nerve wounds would be of considerable interest.

With regard to pain of moderate severity, a neurolysis revealed in 9 cases a small lateral neuroma in the course of the nerve. In all, the operation was followed by some relief for a few days, but, in all, the pain recurred to a greater or lesser extent, and after some months disappeared slowly and spontaneously. The nerves involved were the median in 4 cases, the internal cutaneous in 1, and the sciatic or its branches in 4. The record of one will serve to illustrate them all.

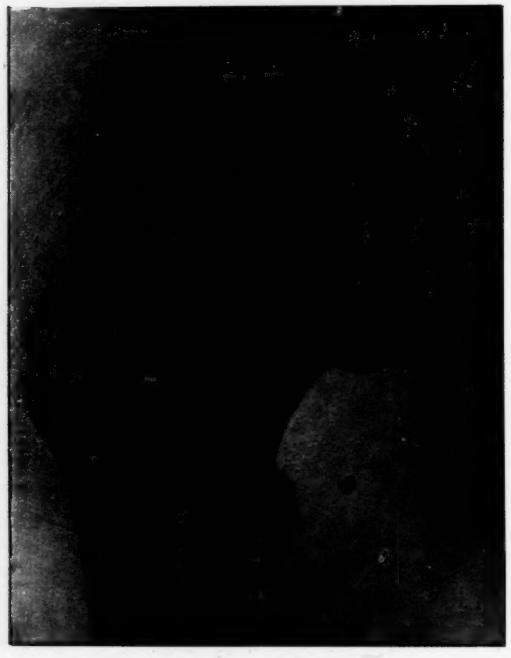

FIG. 390.—*Case* 61. Foreign body causing pain in sciatic.

Case 60.—Pte. G., age 24. Bullet wound of upper third of left arm, September, 1915.

November: Much pain in median area. No paralysis or anæsthesia. Skin of hand pink and sweating. Nails tapering and curved. A pin-prick produces a red spot which remains for two days.

Operation.—Median freed from scar tissue. Nerve swollen and blue-grey, with spots of dark purple colour. On its inner side a small neuroma adherent to the biceps muscle.

December: Relief followed operation for a few days, but pain and tenderness have returned. Skin still glossy and sweating.

May, 1916: Some improvement, but still pain. Vasomotor disturbance still evident.

August: Considerable improvement.

November: Cured.

Summary.—Immediate relief, followed by recurrence of pain, after neurolysis. Gradual spontaneous cure.

Only one case of pain has been seen which could be attributed to the sole factor of irritation by a foreign body.

Case 61.—Pte. C., age 33. Shrapnel wound of left buttock, April, 1917. Entrance left buttock 6·2 cm. behind great trochanter. Severe pain in foot when walking, sitting, or lying down. No paralysis or anæsthesia. *X* ray showed foreign body in neighbourhood of sciatic (*Fig.* 390).

Operation.—Gluteus maximus split. Foreign body found embedded in scar just behind sciatic. Removed.

Immediate and permanent relief of pain.

D. CASES ASSOCIATED WITH ANEURYSMS AND BRACHIAL PLEXUS INJURIES.

Five cases remain to be recorded where a neurolysis was performed for the relief of pain and pressure symptoms resulting from the presence of an aneurysm.

One of these, a case of partial median and ulnar paralysis, associated with severe pain produced by the pressure of a circumscribed traumatic aneurysm of the brachial

in the upper third of the arm, has already been recorded by the writer in this Journal.[16]

The second deserves recording from other points of view than that of the nerve injury, and was of dramatic interest throughout.

Case 62.—L.-Cpl. C., age 28. Bomb wounds of lower third of left arm and left thigh, July 28, 1916.

Notes from France.—Foreign body removed from thigh two days after date of wound. Small suppurating wound of left arm.

Aug. 6: Admitted. Wound of arm healed. Small varicose aneurysm with thrill, murmur, and expansile pulsation of brachial artery. No nerve involvement. Suppurating wound of inner side of left thigh. Intense thrill felt over femoral vessels, and loud machinery murmur heard with stethoscope.

Aug. 9: At 5 p.m. severe secondary hæmorrhage from wound on inner side of left thigh.

Operation.—Ligature of profunda femoris. Thrill and hæmorrhage ceased. Wound opened up on inner side of thigh. Large suppurating cavity filled with blood-clot evacuated. Free venous oozing checked by gauze plugging.

Aug. 10: Temperature 105°. Pulse 140.

Aug. 11–15: Remitting temperature 102°–104°. Pulse 120–140. Patient critically ill.

Aug. 16: Pathologist reported pure growth of streptococci from blood. Wound over femoral vessels suppurating. Stitches removed. Respirations rapid. Patient spitting blood-stained sputum. Vaccine treatment begun, 1 million.

Aug. 19: Patient very alert. Incontinence of fæces. Temperature 103°. Pulse 130. Vaccine, 2 million.

Aug. 22: Patient no better. Passes 4 ounces of blood per rectum. Vaccine, 4 million.

Aug. 23: Femoral artery visibly pulsating at bottom of wound. While dressing, secondary hæmorrhage from common femoral. Ligatured in bed above hole in vessel. Vaccine, 8 million.

Aug. 27: Patient still very ill, and delirious. Leg and foot warm.

Aug. 28: The ligature tied on Aug. 23 ulcerated through vessel wall. Hæmorrhage controlled by patient. Another ligature tied round common femoral just below Poupart. Later, bleeding began again. No more vessel available for ligature. Patient apparently moribund. Firm pad and bandage.

Sept. 1: Patient rallied. No more hæmorrhage. Vaccine, 16 million.

Sept. 6: Patient worse. Temperature 104°. Muttering delirium. Respirations 40.

Sept. 7: Rib resected under local anæsthetic in patient's bed—large empyema evacuated.

Sept. 9: Sensitized vaccine, 30 million.

Sept. 10: Sensitized vaccine, 60 million.

Sept. 21: Temperature normal for first time since admission. Mental condition better.

Oct. 20: Thigh wounds rapidly healing. Empyema closing. Patient much better. Varicose aneurysm of brachial not increased. Sent to auxiliary hospital.

Nov. 2: Returned for immediate operation on arm. Patient in great pain, with complete paralysis of median and ulnar. Huge pulsating swelling of left arm, extending from axillary border to elbow, and very tense. Scar of wound stretched and thin and on point of giving way.

Operation.—Third part of axillary secured. Very large dissecting aneurysm evacuated. Ulnar and median nerves freed.

February, 1917: Still some numbness in median area and weakness in opponens pollicis. Otherwise cured.

Summary.—Paralysis and pain caused by pressure of rapidly increasing varicose aneurysm of brachial, cured by operation.

The remaining three are cases of injury to the brachial plexus associated with the presence of an aneurysm.

Benisty writes: "Lesions of the brachial plexus have a general tendency to recover," which is explained by the fact that the functional disability following injuries of the brachial plexus is at first greater than would be expected from the actual lesions. This is noticeable in the following cases.

Case 63.—Pte. J., age 21. Bullet wound of right chest, May, 1917.

June: Entrance wound 2·5 cm. below right clavicle, over line of axillary artery. Exit near centre of vertebral border of scapula. Both healed. *Main en griffe.* Finger-tips blue. Great pain and tenderness of fingers. Weakness and wasting of whole arm below shoulder. No paralysis. Thrill palpable over wide area round entrance wound. Machinery murmur, conducted into the neck and as low as bend of elbow. No heart murmur. Thrill and murmur suppressed by digital pressure of subclavian. Radial pulse very weak on right side.

July: No improvement.

Operation.—Vertical incision. Subclavian exposed, and controlled with loop of ligature. Division of clavicle. Artery, vein, and cords of brachial plexus dissected from scar and identified. Aneurysmal varix found opposite point of origin of thoracic axis (*Fig.* 391). Vein hugely dilated below point of communication. Communication between vessels more clearly defined, and ligatured. Thrill immediately ceased and radial pulse became perceptibly stronger. Clavicle wired. Wound closed.

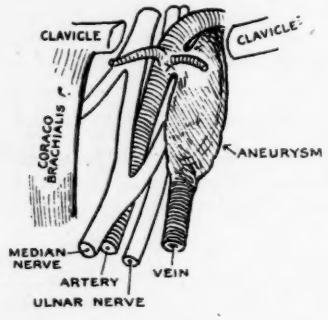

FIG. 391.—*Case* 63.

Aneurysmal varix of first portion of axillary vessels.

October: All movements of arm good. Nutrition of muscles improved. No pain in hand. Soft systolic bruit heard over site of ligature. No thrill and no machinery murmur. Transferred to military convalescent hospital.

Summary.—Aneurysmal varix of first part of axillary, complicating compression of brachial plexus by scar tissue. Cured by operation.

Case 64.—Pte. R., age 21. Bullet wound of right shoulder, July, 1916. Wrist-drop. Loss of sensation in little and ring fingers.

September: Paralysis and R.D. in all musculospiral muscles, including triceps. Loss of sensation in ulnar area. Paralysis with R.D. in flexor carpi ulnaris, ulnar half of flexor profundus, and interossei. Wasting and weakness in median muscles, without paralysis. Much pain and tenderness in median sensory area. Musculocutaneous not affected.

October: Unchanged.

Operation.—An incision beginning near inner end of clavicle, and 1 cm. below, was carried outwards as far as the coracoid process. Turning down along the groove between the deltoid and pectoralis major muscles, it ended in the arm 2·5 cm. below the anterior axillary fold. Pectoralis major and minor divided near their insertions, and cutaneo-muscular flap turned inwards and downwards with its vascular and nervous supply intact. Small circumscribed traumatic aneurysm of second part of axillary (*Fig.* 392). Vessel tied above and below and aneurysm removed. Nerves freed from scar. Small lateral neuroma of median.

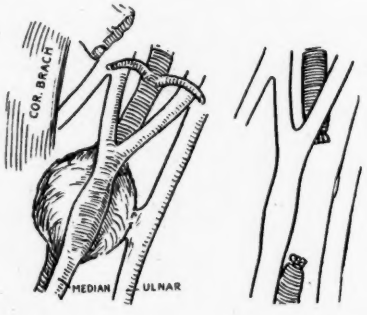

FIG. 392.—*Case* 64.

Circumscribed traumatic aneurysm of axillary artery, with injury to brachial plexus. Before and after removal of aneurysm and neurolysis.

March, 1917: Triceps, extensors of wrist, and fingers recovered. Ulnar condition unchanged. Less tenderness in median area.

June: Recovery beginning in ulnar. Voluntary power in flexor carpi ulnaris. Interossei and small muscles still paralyzed.

Summary.—Circumscribed traumatic aneurysm of axillary, with injury to brachial plexus. Considerable improvement 8 months after operation. Slow recovery of ulnar.

Case 65.—Pte. S., age 19. Bullet wound of right shoulder in Mesopotamia, April, 1916. Gradually increasing wasting and weakness of right arm.

July: Whole arm below shoulder wasted. Weak voluntary power in biceps, brachialis anticus, coracobrachialis, deltoid, triceps, and extensors of wrist. Paralysis of extensors of fingers, with absent faradic response but brisk galvanic. Complete paralysis with R.D. of all median and ulnar muscles, with corresponding complete anæsthesia. Large hard mass filling up axilla. No pulsation felt.

Operation.—Exposure as in last case. Very large circumscribed traumatic aneurysm of second part of axillary, extending far down between the latissimus dorsi muscle and chest wall. Artery tied above and below. Sac opened and contents evacuated. Median and ulnar nerves spread out and thinned on anterior surface of sac. Nerves freed.

November: Voluntary power in extensors of finger and thumb. Recovery of protopathic sensation in median sensory area. Voluntary power in flexor carpi radialis. Ulnar condition unchanged.

March, 1917: Continued improvement in median. Voluntary power in flexor sublimis and pronator radii teres. No recovery of voluntary power or sensation in ulna. Tinel's sign half-way down forearm over ulnar.

August: Faradic response in all median and musculospiral muscles. Ulnar muscles still paralyzed, with R.D.

October: Recovery of protopathic sensation in ulnar area. Voluntary power in flexor carpi

ulnaris and flexor profundus. Great improvement in nutrition of hand. Discharged to Command Depôt.

Summary.—Large traumatic aneurysm of axillary, causing paralysis in musculospiral, median, and ulnar. Considerable improvement 15 months after operation.

4. ALTERNATIVE OPERATIONS.

Substitution of the action of the pronator radii teres, flexor carpi ulnaris, and flexor carpi radialis for that of the normal extensors, to render practicable extension of the wrist, fingers, and thumb in cases of irreparable injury to the musculospiral, has been carried out in 4 cases.

The writer cannot agree with Souttar that such operations will be only rarely required. The functional results in this operation are so excellent that it should be regarded as the operation of choice whenever the musculospiral is incapable of repair without the sacrifice of bone or interference with a neighbouring nerve.

A point of great importance in obtaining a good and rapid result is the preliminary education of the muscles which are to be used for the substitution.

The following case is the counterpart of the remainder.

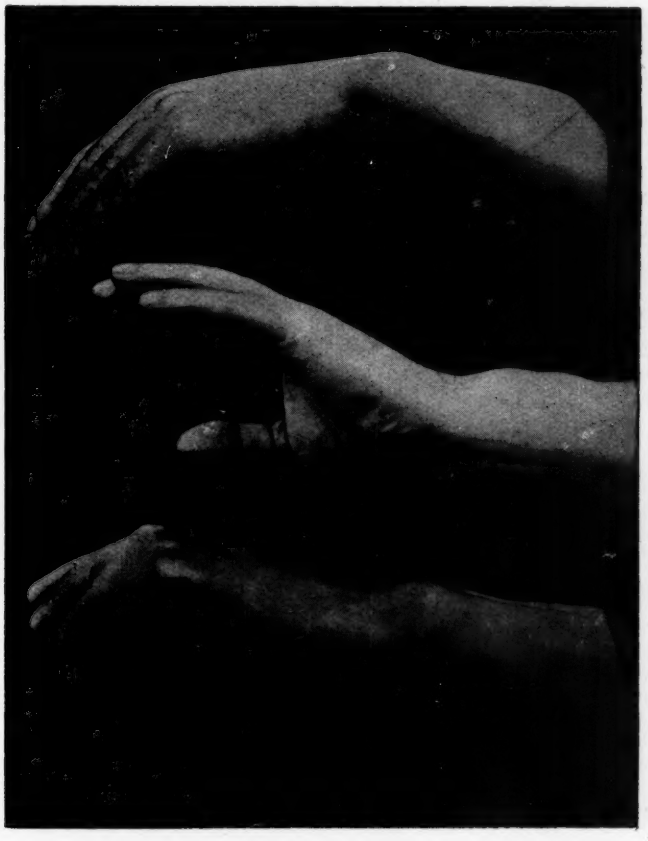

FIG. 393.—*Case* 66. Function of hand after alternative operation for complete musculospiral division

Case 66.—Pte. P., age 36. Shrapnel wound of left arm, with compound fracture of humerus, August, 1917.

Notes from France.—Posterior cord of brachial plexus severed, 5 cm. destroyed.

October: Wound of axilla healed, leaving very large dense scar. Tinel's sign over scar along radial sensory area. Complete paralysis with R.D. of musculospiral muscles below elbow.

January to April, 1918: Muscle education. Patient taught independent control of flexor carpi radialis, pronator radii teres, and flexor carpi ulnaris.
April: No recovery in musculospiral. Tinel's sign has not spread.
Operation.—Alternative operation described by Sir Robert Jones.
June: Excellent result (*Fig.* 393).

A case of open division of the tendons of the external rotators of the thigh, for a tonic spasm of these muscles following an irritative lesion of the obturator nerve, is, perhaps, on account of its rarity, worthy of record.

Case 67.—Pte. S., age 20. Shell wound of left groin, December, 1917.
January, 1918: Complains of pain in region of left hip. Walks badly, with leg everted (*Fig.* 394 *a*). *X* ray shows foreign body in obturator foramen 15 cm. from surface.

a b

FIG. 394.—*Case* 67. Injury to obturator nerve, causing spasm of external rotators of thigh.
a. Before; *b*. After division of tendons.

March: No improvement.
Operation.—Foreign body removed. Obturator nerve freed from scar tissue.
April: No improvement in spasm of external rotators of thigh.
May: Correction of position in plaster-of-Paris.
June: No improvement.
Operation.—Through open incision, tendons of obturator internus and externus divided near their insertions.
July: Walking well. Condition cured (*Fig.* 394 *b*).

5. UNOPERATED CASES.

These number 55. They are divisible into two groups: (*a*) Complete physiological division, 29 cases; (*b*) Incomplete physiological division, 26 cases.

a. COMPLETE PHYSIOLOGICAL DIVISION.—*Table VIII* shows the results in the 29 cases in this group.

Table VIII.—Unoperated Cases of Complete Physiological Division.

Recoveries (April, 1918)	Considerable Improvement	Improvement	No Result
8	7	2	12

Of the 12 cases labelled 'No result,' 2 were cases of musculospiral injury, and afterwards had an alternative operation performed; 3 have since been operated upon—two sutures and one neurolysis capsulectomy; 3 await operation; 2 were transferred to other hospitals; and 2 refused operation.

Of the 17 cases which recovered or improved, 6 were cases of nerve concussion, and cleared up in less than six weeks from the date of injury; the fate of the remaining 11 is shown in *Table IX*.

Table IX.—Details of Improved Cases.

	Recovered	Considerable Improvement	Improvement
Number of cases	5	4	2
Average time from date of wound	13 months	11 months	8 months
Longest time „ „	18 „	13 „	10 „
Shortest time „ „	10 „	8 „	6 „

These cases are not recorded in detail, but the general results given in *Table IX* are of more than ordinary interest. At their beginning the cases showed complete paralysis with R.D. in the affected muscles, and complete sensory loss, yet they recovered spontaneously along the lines which would be expected to follow a primary suture. The record of one case will be a sufficient commentary on the remainder.

Case 68.—Pte. L., age 19. Through-and-through bullet wound across right popliteal space, March, 1917. Foot-drop.

April: Complete external popliteal paralysis with R.D., and complete sensory loss.

September: No change.

October: Protopathic sensation recovering. Still some loss of epicritic. Formication on percussion over head of fibula. Still paralysis and R.D. in muscles.

November: Voluntary flicker of peronei visible. Epicritic loss diminishing.

January, 1918: Voluntary power in tibialis anticus.

August: Voluntary power and faradic response in all muscles supplied by external popliteal. Pin-prick and brush everywhere felt.

Summary.—Spontaneous recovery after 16 months.

The question may well be asked: What condition of the nerve would have been found had exploration been performed at the end of five months, when to all appearance the patient suffered from a complete division of his external popliteal? While proof is impossible, there is strong presumptive evidence that these cases are those with spindle-shaped neuromata. Compare *Table IX* with *Table VI*, and note the extraordinary parallel between the average time from date of wound to date of improvement and recovery in those cases known to be neuromata and in those which recover spontaneously.

At present, unless many months are allowed to elapse, and unless frequent examinations are made, there are no means of distinguishing between a nerve which has undergone complete anatomical section, and one injured, which is about to undergo, but has not yet undergone, spontaneous repair.

Are we then to wait six to eight months before exploring? Quite definitely, No! Any case with evidence of complete physiological division should be explored as soon as the condition of the wounds admits—if for no other reason than that a complete section

may be found, and so allow of operative repair being undertaken at the earliest date possible. But the writer would enter an earnest plea against exsection of spindle-shaped neuromata, whether hard or soft, whether conducting the faradic current or not, at any period earlier than ten months after the injury.

b. INCOMPLETE PHYSIOLOGICAL DIVISION.—The fate of these 26 cases is shown in *Table X.*

Table X.—UNOPERATED CASES OF INCOMPLETE PHYSIOLOGICAL DIVISION.

RECOVERY	CONSIDERABLE IMPROVEMENT	IMPROVEMENT	NO RESULT
16	7	2	1

SOME GENERAL REFLECTIONS.

It has been quite impossible to study this series of cases without reflecting on some of the dark and unsolved problems of nerve regeneration. Let it be said at once that Cone's researches have been a fruitful source of inspiration, and have explained many points which were obscure. In these reflections, the spindle-shaped neuroma has loomed large.

The writer has not seen any case of complete physiological division later than twelve months after injury in which the condition was not a complete anatomical section. On the other hand, many cases with palpable spindles on their nerves have been seen with full and complete recovery. A series of cases in which this condition was present, the majority of which recovered, all of which improved, has been recorded in this paper. A further series of spontaneous recoveries in which there is presumptive evidence that the same condition exists has been noted.

Cone has made a series of remarkable experiments on the growth of nerve tissue taken from war-injured nerves and transplanted into guinea-pigs. From these he concludes that war-injured nerves are ready to unite at both ends of the injury before the end of eight months. These findings receive striking clinical confirmation in the writer's cases by a comparison of the average time from wound incidence to date of improvement noted in *Tables VI* and *IX*. The single case in the series which most bears on this question is *Case* 7. Here definite evidence is available that spindle-shaped neuromata had formed at both ends of a nerve transplant where it joined the injured nerve, and that both transplant and injured nerve had shared in their formation. At the end of ten months axis cylinders had grown through both spindles as well as the transplant.

Have these facts any bearing on the technique of secondary suture? Delagenière, writing of suture, says, "A neuroma is found on the central end, a pseudo-neuroma on the peripheral end. Both are obstacles to regeneration and must be resected and the freed axis cylinders of both ends put in contact." Souttar, after dividing the nerve as near to the point of injury as is compatible with the presence of healthy fibres in the divided end, examines that end, and if the nerve bundles do not appear sufficiently normal, a further slice is removed. Kennedy[17] says, "In all cases it is most essential to see the normal appearance of the fasciculi in the nerve section, and slice after slice must if necessary be cut from the nerve end until this is attained, not only in the central but also in the peripheral end." Further on, he says, "It is not safe to reunite a nerve trunk by means of the bulbs: some result might be obtained in this way, but it is apt to be imperfect; the connective-tissue element in the bulb may contract and interfere with the conductivity. It is therefore right to remove the bulbs entirely." The writer does not know whether these last remarks on the reunion of nerve trunks by the bulbs are the result of clinical observation of cases so treated, or whether they are merely the *a priori* reasoning from histological researches. But the point in question is one of great and

immediate importance. All the suture cases in this series have been dealt with by the method advocated by these writers, yet few, if any, have equalled either in rapidity or completeness the recoveries which occur after neurolysis capsulectomy or after spontaneous cure. May not the bulbs be the two separated halves of a spindle-shaped neuroma? Moreover, in all recovering cases in which the suture line of a repaired nerve was available for palpation, a small spindle-shaped swelling has been felt. Kennedy has also apparently noticed this, for in advocating dislocation of a sutured ulnar nerve to the front of the epicondyle, he gives as his reason, "that the enlargement which forms at the seat of suture compresses itself against the rigid boundaries of the sulcus and thus prevents conductivity." In other words, after a resection suture, the nerve re-forms a spindle-shaped neuroma in the course of its repair. The matter is one which can be settled only by an appeal to treated cases, and, with this end in view, the writer has now under observation three cases in which, after performing a capsulectomy of the bulbs, the nerve trunk has been reunited by their suture. It is hoped to report the result of these cases in a later communication.

CONCLUSIONS.

1. In the majority of cases, delayed end-to-end union of a divided nerve is successful, and this method of repair is that of choice.

2. There is something to be said for reunion of nerve trunks by suture of bulbs. An apeal to the results of cases so treated is the only way of settling this important matter. This is being done.

3. The anatomical continuity of a nerve deserves the greatest respect.

4. Exploration of a physiologically completely divided nerve should be done as soon as the condition of the wound permits.

5. Neurolysis combined with a capsulectomy of spindle-shaped neuromata has been followed by recovery in most, and improvement in all, cases in which this has been done.

6. Exsection of a spindle-shaped neuroma is not justified unless failure has resulted from a neurolysis capsulectomy.

7. Nerve transplantations, and double lateral implantations of the ulnar into the median in the forearm, have been followed with some measure of success, including some recovery of voluntary power in the affected muscles; but recovery is slow and uncertain.

8. Nerve growth takes place from both ends of a divided nerve, and from both ends of a nerve transplant, but axis cylinders grow down only from the central end.

9. An autogenous nerve transplant, of smaller size than the nerve into which it is planted, is capable of hypertrophy.

10. Axis cylinders, judged by Tinel's sign, grow at the average rate of 2 mm. per diem.

11. Perineural scar tissue constricting young axis cylinders is the most important factor in hindering recovery.

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[17] Kennedy, *Ibid.*, 1918, vi, 318–321.

FRACTURE OF THE FEMUR: A METHOD OF HOLDING THE FRAGMENTS IN DIFFICULT CASES.*

By Captain DENNIS W. CRILE, R.A.M.C., Harvard Unit, B.E.F.

Special Military Surgical Hospital, Edmonton.

Some fractures of the femur resist all attempts to maintain reduction by ordinary means. Lane's plates, screws, wiring, medullary pegs, and bone grafting, all have the disadvantage of introducing a foreign body into a septic or potentially septic wound, and this renders them inapplicable to most compound fractures. Hey Groves' apparatus has several disadvantages: its application involves a complicated operation in the depths of the limb; it may involve opening the marrow cavity; and it does not give absolute immobility to the fragments. The apparatus here described was designed to meet the requirements of these difficult cases, and may be applied in any case in which the great trochanter and condyles are intact, regardless of the site of fracture or degree of comminution. It is an attempt to procure absolute fixation by external means. The one possibility of failure is that of sepsis developing in the cancellous tissue of the great trochanter, which possibility should be negligible with careful asepsis.

The apparatus is made of steel throughout, and the principle which makes it possible is that of a locking universal joint. A peg (1, *Figs.* 395, 396), rectangular in cross-section is designed to be driven into the great trochanter until it meets the firm resistance of the calcar femorale (*Figs.* 397, 398). No preliminary drilling should be done, thus ensuring the least possible destruction of bone, and preventing the possibility of contamination by several different instruments. The two narrow surfaces of the peg taper slightly towards the chisel-shaped point, the cutting edge of which is made by bevelling the two broad surfaces. This shape is an adaptation of the principle of the square nail which joiners use to avoid splitting. In driving a square nail, the parallel sides are in the plane of the grain of the wood—the taper crosses the grain—and in this way the peg should be driven into the bone. This will not split even a dry bone. The chisel point prevents the possibility of driving bits of cortex ahead of the peg into the cancellous bone, while the taper ensures its being firmly seated. The butt end which protrudes beyond the skin is a ball.

The condyles are grasped by double-pointed calipers (9, *Figs.* 395, 396), made firm by a transverse screw (8), which approximates the points when tightened. There is abundant room in a longitudinal direction on the condyles for these double-pointed calipers, which have the advantage of absolute control over the lower fragment, as against the partial control of the single-pointed instrument. They can be used without the rest of the apparatus for extension and elevation of the lower fragment in supracondylar fractures (*Fig.* 395). A ball (7) is fixed to the arch of the caliper body.

The two balls, one fixed to the trochanter (1) and one to the condyles (7), are connected by a telescoping steel bar, on either end of which a socket receives the respective balls. Each of these sockets is fitted with a locking screw (2, 6), which, when set, converts the ball-and-socket joint into a fixed angle. The length between the two ends of the telescoping rod is increased or diminished by a screw which runs through

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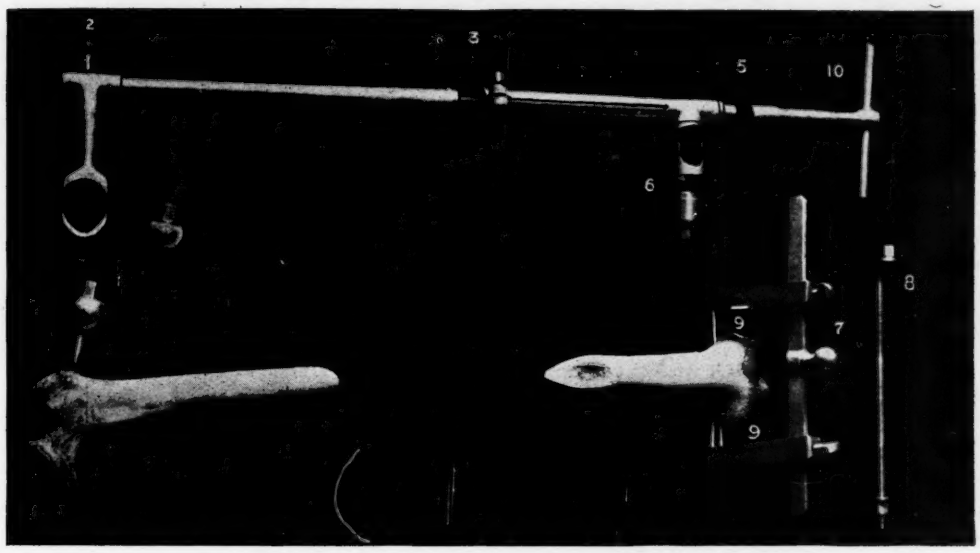
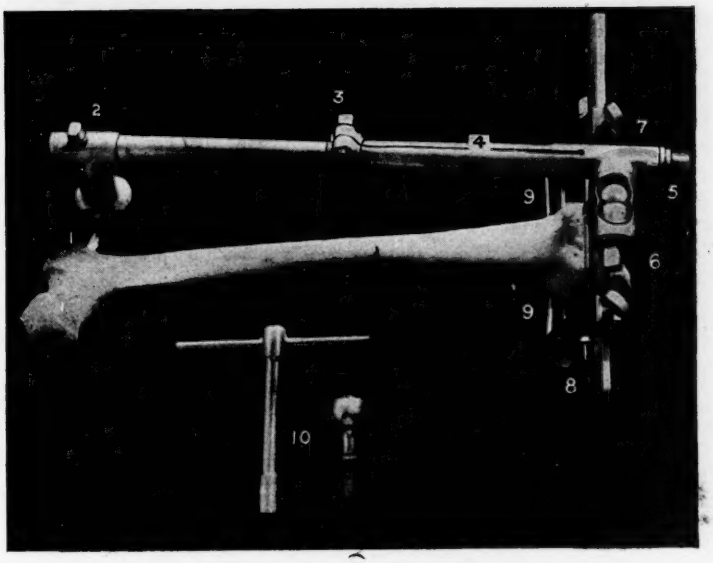
* Messrs. Allen & Hanburys, 48, Wigmore Street, London, have a model of this apparatus, and can supply it to order. Also the American Red Cross (Splint Department), Paris, have a model, which may be obtained by applying to them at 4, Place de la Concorde.

it (4). The outer tube is slotted and fitted with a locking collar (3). Thus, the bar can be twisted on itself to any degree, and locked Every possible relation can then be produced between the great trochanter and the condyles.





FIGS. 395 and 396.—Illustrating the parts of the apparatus. (The apparatus has been simplified since this case was treated.) (1) Peg and its socket. (2) Lock-nut for trochanteric socket. It is in an easily accessible position. (3) Locking collar and length screw (4). (5) Nut for length screw. Note easily accessible position. (6) Nut for condylar socket. (7) Ball attached to condylar calipers. (8) Transverse condylar screw for gripping condyles. This is not needed on the later model. (9) Double caliper points. (10) Wrench which fits all nuts.

Case Report.—L.-Cpl. C., wounded April 5, 1918, by bullet driving contents of pocket into thigh.

OPERATION on April 6, at C.C.S.; wound excised, bullet removed. April 8. Admitted to general hospital on Thomas splint, general condition poor. Abduction 30°, 15 lb. weight and pulley extension. April 16. *X* ray shows over-abduction of lower fragment. April 22. Abduction 15°; 20 lb. extension; splint changed from large to small ring Thomas. On April 25, *x* ray shows

upper fragment persists in adduction (*Fig.* 399). Adduction 10°. May 5. Genuflexion 20° ; adduction 20° ; 20 lb. extension. May 10, despite all attempts to hold the fracture in position, malposition recurs. Skin over great trochanter dressed with alcohol for forty-eight hours.

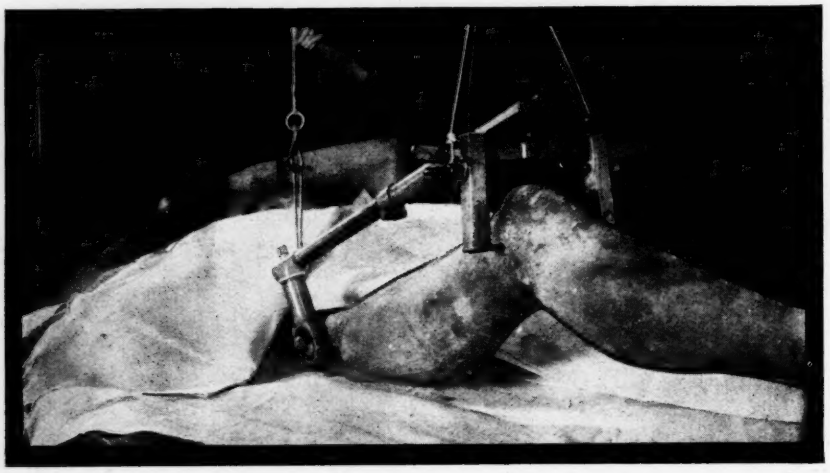


FIG. 397.—Apparatus with dressings removed. The entire thigh is free for inspection and dressing. Note the dependent posterior drainage incision (made May 18); the normal outline of thigh; the absence of inflammation about trochanter and condyles; and also the preservation of the musculature of calf, due to active exercise of ankle and knee.

FIG. 398.—Apparatus with dressings in place and rope suspension of thigh and foot. The ropes are carried over pulleys with counterweights attached, thus permitting each rope to be moved independently. The dressings over the peg and the caliper points were changed only three times in 24 days.

SECOND OPERATION.—May 12. Ether anæsthesia. Thomas splint removed. Incision one inch long made longitudinally over great trochanter, carried to the bone, and packed with dry gauze until oozing ceased. It was then dried with alcohol, and a small amount of B.I.P.P. rubbed into the incised skin and subcutaneous tissues. The steel peg was now driven directly into the bone by blows from a steel hammer until the point seemed firmly embedded in the

calcar femorale. A dry dressing was applied, leaving the ball of the peg protruding. Incisions one inch long were made over the condyles in a longitudinal direction. They were packed with gauze until all oozing ceased, dried with alcohol, and rubbed with B.I.P.P. The double-pointed calipers were affixed to the cortex of the condyles, and dry dressings applied. This technique provides for the driving of the peg and the application of the calipers to be made through an antiseptic—B.I.P.P.—a small amount of which the peg carries with it into the medulla of the trochanter, where it acts as a barrier to possible infection.

The connecting telescopic bar was now put in place. The ball-and-socket joints were not yet set. The fracture was then reduced while an assistant set the locking-screws. The length of the femur can be controlled either at once (which I did), or subsequently in stages, by simply screwing the telescopic arrangement. The patient was put in bed, and counter-weights were arranged to support the weight of the leg (*Fig.* 398).

A discharge from the anterior wound, which had been about a drachm of thick pus daily,

FIG. 399.—Radiogram taken April 25 on Thomas splint shows upper fragment in adduction. There is shortening of 1½ in. This is practically the same as the radiograms taken on Aprfl 16 and early in May

ceased from May 12, only appearing on May 17, and therefore indicating pocketing posteriorly due to the absence of the supporting bands.

THIRD OPERATION.—May 18. Chloroform. Posterior drainage established. Correction of position of bones with fingers in the wounds while an assistant tightened up the screws.

June 4. Position good (*Fig.* 400): 1½ cm. over-length, no fever, pulse normal. Active motion knee 35°. Ankle normal. Hip slightly limited. Patient has been able to sleep on his side and to move about actively in bed. Up in chair to-day with apparatus in position. June 5. Plaster cast applied. Splint removed. Considerable force was required to loosen peg in great trochanter. No evidence of rarefaction about peg. Cultures taken from peg in bouillon and on agar were sterile. June 9. Discharged to England, soft union, good position, general condition good. Wounds over condyles and great trochanter sealed with dried serum.

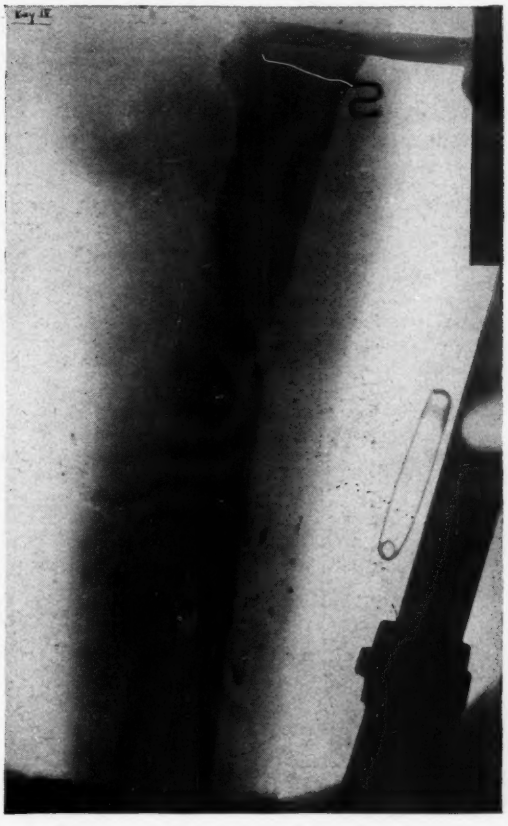


FIG. 400.—Radiogram taken June 2 shows final antero-posterior position.

This apparatus makes the patient *comfortable*, produces and maintains accurate reduction of his fracture, eliminates support bandages which obstruct dressing and free drainage, and leaves the hip, knee, and ankle-joints free for early passive motion. The bed can be left in its flat position rather than elevated at the foot, so that there is no tracking

upwards of pus. It allows active motion so soon as infection clears up. The patient reported above was able to extend his knee *actively* two weeks after the appliance was put on. These advantages are the result of the absolutely rigid fixation which is obtained. There is no transfixion of bone ; there are no parts buried deeply in muscular substance ; the points of application are at the limits of the bone and are subcutaneous ; the peg in the trochanter, being rectangular in section, gives a purchase for flexion or extension of the upper fragment ; there is no danger of involving the knee-joint by piercing the intercondylar notch ; all parts can be locked ; and finally, it produces rigid immobility, and it can be applied to the fracture in its unreduced position, and reduction accomplished as well as maintained by the instrument. Its application is simple and easy.

It is applicable to any case where plating and wiring would be indicated, and does not have the disadvantage of introducing a foreign body into the wound or its neighbourhood.

I hesitate to publish this report based on only one case, but since the war promises to be over soon, and since the apparatus was so satisfactory in its performance, it seems advisable to bring it to the attention of those who may have difficult cases of fractures of the femur. It has been applied to more cases recently, and promises to give equally satisfactory results, which I may report at a later date.

I desire to acknowledge my indebtedness to the work done by Lieutenant-Colonel Beasley, M.C.N.A., U.S.A., in demonstrating the utility of the caliper which has made this instrument possible. I am indebted to Major E. Granville Crabtree, R.A.M.C., Harvard Unit, and to Mr. G. A. Mower, of the Sturtevant Engineering Company, for valuable mechanical suggestions. Through the kindness of Lieutenant-Colonel Hugh Cabot, R.A.M.C., Harvard Unit, and Lieutenant-Colonel Spencer-Mort, R.A.M.C., I am permitted to publish this paper.

THE RECOGNITION AND SIGNIFICANCE OF FRACTURES OF THE PATELLAR BORDER.

By Captain R. W. A. SALMOND, R.A.M.C.
Deputy Consulting Radiologist, British Armies in France.

The object of publishing these observations is to bring to notice the occasional presence of fissures on the outer border of the patella, the importance of which, it is thought, has not been hitherto very generally recognized.

From notes both clinical and radiological, these fissures are found to be caused by some slight *indirect* injury or strain, such as a twist of the knee from overstepping the curb or from vigorous physical exercise. The injury may be so slight that it is difficult to obtain any definite history of it, and at the time of occurrence the patient does not generally realize that anything very unusual has happened. In this respect the condition somewhat resembles the recently described marching fracture of the metatarsals.

The notes of the following case are given as fairly typical:—

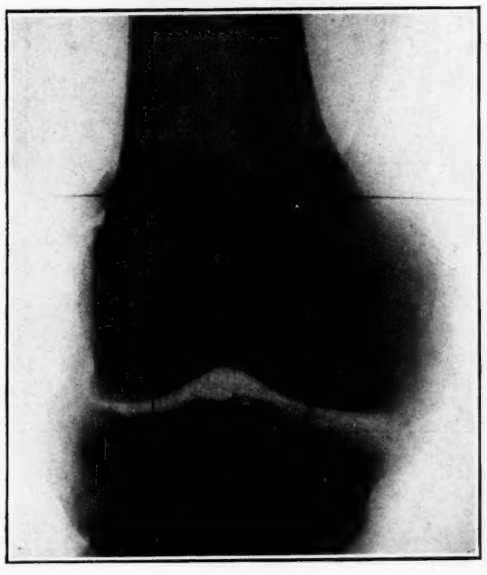


Fig. 401.

Fig. 402.

J. P., age 23, was admitted to hospital for an operation for inguinal hernia. He also mentioned that there was a feeling of discomfort and weakness at both knees. Previous to the war he had been a clerk in the City, and had not felt anything wrong with his knees. Pain was first noticed while he was doing physical exercises, fourteen months previously; later, a feeling of weakness at both knees developed after walking for some distance, as if they were giving way. He was very definite that there had been no trauma to either knee. Patient walked in the usual way, and could flex and extend freely both knee-joints, though a certain amount of discomfort was caused in doing the latter. A longitudinal linear depression could be felt toward the outer border of each patella. On moving the bone on either side of it, there was no crepitus, but some tenderness was caused.

Radiographic Examination.—*Right patella*: Anterior view shows a longitudinal fissure near the outer border, and the separated portion fissured into smaller fragments (*Fig.* 404).

Stereoscopic external lateral view shows the detached fragment to be made up of three pieces. *Left patella*: Anterior view shows a longitudinal fissure in same position as opposite side, the separated fragment being of oval shape. Stereoscopic external lateral view confirms the anterior view. The other bones of both knee-joints are quite normal.

Treatment by electric baths, massage, and gentle exercises was tried, but without any improvement in the condition.

Varying degrees of fissure may be observed, from a slight crack with no displacement, to the greater part of the whole border of the patella detached, with, later on, callus thrown out to bridge the gap. The latter condition does not come under the category of fissure fracture, but is included here as being a transition between this and the classical fracture of the patella by muscular action. It is with the former, however, that this paper is intended to deal.

In a series of eight cases of fissure fracture observed, it is noteworthy that in no case was the patient sent to the *x*-ray department for the determination of fracture of the

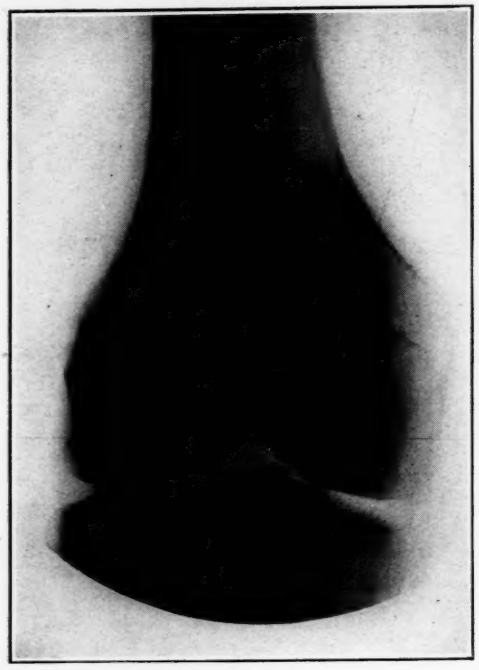


FIG. 403.

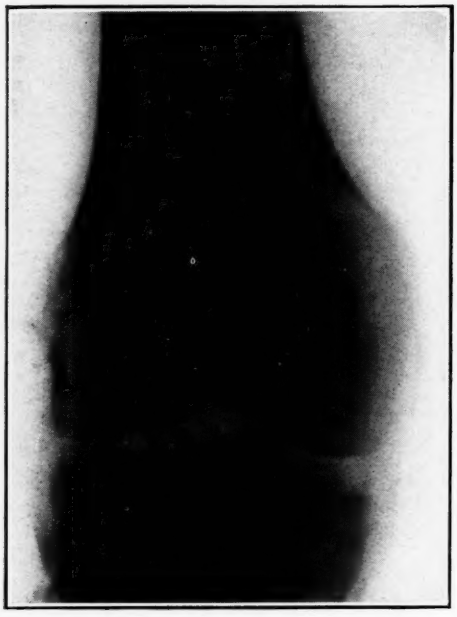


FIG. 404.

patella, but for some such condition as 'synovitis,' 'arthritis,' 'something unusual about bones of knee-joint,' etc.; while in every case he was able to walk up for examination. This is mentioned to show how frequently the question of fracture in these cases is quite unsuspected by the clinician.

Radiological examination shows that the fissures are situated at the outer border or at the external superior angle of the bone. This position would correspond to the line of tension of an overstretched articular capsule, as in lateral bowing of the limbs, or to where the pull of the vastus externus muscle is experienced. A selection from a series of cases showing changes varying from a fine fissure without displacement to a much more extensive condition approaching in character the well-known indirect fracture by muscular action is given in *Figs.* 401–405, and would suggest that the former injuries are either a minor degree of the latter, with the line of force acting in a slightly different direction, or that they are due to an overpull of the ligaments, as in the so-called sprain-fracture.

Radiography.—The technique employed is to take an anterior view of the joint, and stereoscopic external laterals. The latter should always be made, as they will often show the fissures to be multiple, and as many as five distinct fragments have been seen. A posterior view of the joint is of little or no value, on account of the distortion of the patella. Screening alone for the determination of this condition is, of course, quite useless. There seems to be only one condition that might be mistaken for the one described, and that is when the shadow of a sesamoid bone in the outer head of the gastrocnemius muscle just overlaps the edge of the patellar shadow in the anterior view. The lateral plates will help to settle this point.

Treatment.—If the condition be recognized at the time of occurrence, immobilization of the affected limb or limbs with the leg extended for one or two days, but with passive movements started as soon as any hæmorrhage is believed to have ceased, would allow the fragments to join up to the parent bone without any separation. Cases so treated, and with no *x*-ray examination revealing the fracture at the time of occurrence, would leave no trace of the condition for diagnosis at a later date.

FIG. 405.

If the condition is not recognized at the time, and the patient is allowed to go about, the small fragment or fragments will be constantly moved against each other and the main bone, and a sort of fibrous union will take place, which is liable to be upset by any extra strain put on the joint ; indeed, it would appear that the condition is quite as often brought to light by this secondary state as by the primary one. The feeling of weakness in the knee is also liable to increase under extra strain, and be accompanied by effusion into the joint, giving rise to recurrent synovitis.

The outlook in cases diagnosed at once would appear to be very good ; but in cases with only fibrous union there is the likelihood of some permanent weakness at the joint —depending on the degree of fracture—for which it is difficult to do much, apart from avoiding any undue strain.

It is hoped that these observations on fissure fractures of the patella will draw attention to the importance of early and accurate diagnosis and suitable treatment in the case of seemingly trivial injuries and complaints about the knee-joint.

SUMMARY.

The chief points in this condition are :—

1. The difficulty of obtaining a definite history of trauma, though on careful interrogation a story of some slight indirect injury may be elicited.
2. It may be right-sided, or left-sided, or both, according to the exciting cause.
3. The seat of any discomfort or pain is usually on the inner side of the patella, while the fissure fractures observed have been without exception on the outer border.
4. The direction of the line of fracture is either longitudinal, or obliquely downwards and outwards, but not transverse as in the usual muscular fracture.
5. A linear depression may be felt, corresponding to the line of fissure ; pressure of the bone on either side of this may elicit separate movement, and generally tenderness, but not crepitus.
6. Synovitis is frequently present, or has been at some previous date, caused partly by the tearing of the synovial membrane with the fissuring of the posterior surface of the patella, and it is prone to recur.

SHORT NOTES OF RARE OR OBSCURE CASES.

AN UNUSUAL TYPE OF FRACTURE DISLOCATION OF THE UPPER END OF THE HUMERUS.

By Captain TREVOR B. DAVIES, R.A.M.C. (T.C.)

Lance-Cpl. J. T. was admitted into hospital on July 14, 1918, having been thrown twice from his horse within a few minutes, alighting each time on his right shoulder. He was helped on to his horse after the first fall.

X-ray examination showed a subcoracoid dislocation of the head of the humerus, together with a spiral fracture passing downwards and inwards from the outer part of the head, ending on the inner aspect of the shaft of the bone just above its centre (*Fig.* 406).

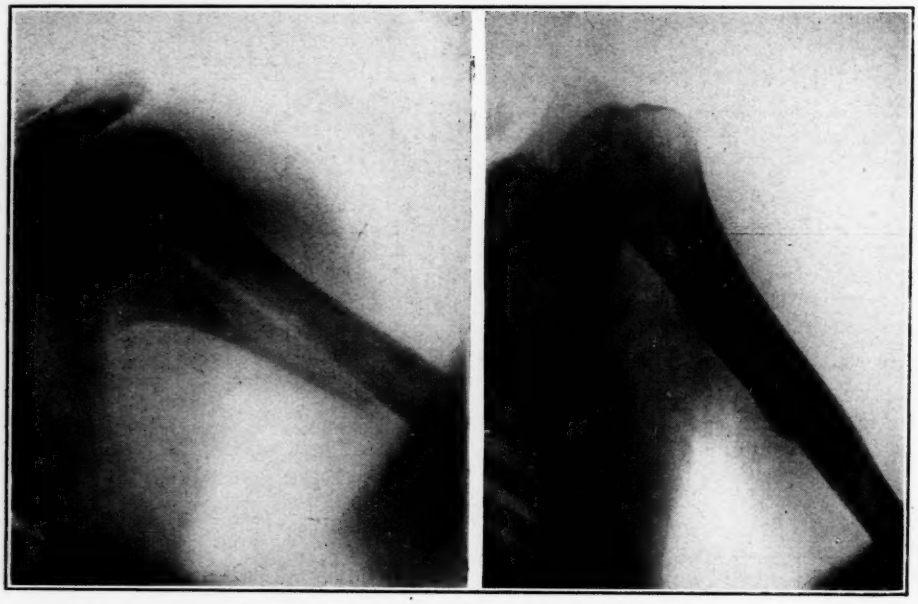


Fig. 406.

Fig. 407.

Under a general anæsthetic the joint dislocation was reduced by a combination of Kocher's method and manipulation of the upper or inner fragment. The fracture was then reduced, and the arm bandaged to the side of the body. No splint was used. The *x* ray taken immediately afterwards showed the fragments to be in good position and the dislocation satisfactorily reduced. Passive movements of the limb were begun a week later, and at the end of a fortnight the patient was encouraged to move his arm.

An *x*-ray plate taken seven weeks after the accident showed union in good position (*Fig.* 407), and the patient left hospital a few days later with practically normal power of movement in the right shoulder.

A CASE OF SEPTIC INFARCT OF THE SPLEEN, CAUSING RUPTURE OF THE SPLEEN, HÆMORRHAGE, AND DEATH.

By ALAN H. TODD, London.

Pte. T., age 40, was wounded by a shell on Dec. 19, 1917, and sustained flesh-wounds of the left arm, shoulder, and thigh, and a compound fracture of the right leg. At No. — C.C.S. it was found that the right anterior and posterior tibial arteries were torn, and that there was gas infection of the tissues of the leg. Supracondylar amputation by the flapless method was performed, and 500 c.c. of blood were transfused. The wound of the left thigh was excised, and a metallic fragment removed; the wound was plugged with gauze soaked in Dakin's solution, and both were dressed with Morison's B.I.P.P. paste. On the following day the transfusion was repeated, 500 c.c. being given. On Dec. 21, at No. — General Hospital, it was recorded that the wounds were 'fairly clean.'

On Dec. 28, the patient was admitted to Lewisham Military Hospital. The amputation wound was exuding much thick green pus, and granulations were exuberant and foul. Two days later a dose of 500 c.c. of A.T.S. was given. On Jan. 3, 1918, the patient had an irritating cough, and some expectoration; he stated that he had 'always' had bronchitis in the winter, and that he had had it prior to his return to England. His temperature showed a moderate irregular pyrexia. He was raised in bed, and a simple expectorant ordered. His general condition was only moderately good. On Jan. 9 (six days later), he complained one night of a sudden stabbing pain over the left lower ribs; he was examined by the orderly officer, who could hear nothing abnormal with the stethoscope, but thought that the trouble was probably pleurisy, and ordered morphine hypodermically. Five hours later the patient collapsed very suddenly, and died before medical aid could be obtained.

At the post-mortem it was found that though the amputation stump was soaked with stinking green pus, the right and left femoral and iliac veins were perfectly healthy; there was not the slightest roughening or injection of the intima, nor any suggestion of past or present clot in them. The pelvis and left hypochondrium were full of blood and recent clot. The spleen was torn right across, and had bled profusely; a great mass of loose clot protruded from it. The spleen pulp, as much of it as was recognizable, was very soft, and there was a thick coating of fibrin on the exterior of the organ—evidence of recent perisplenitis. The capsule of the spleen was firmly adherent to the diaphragm, the muscle of which, in the neighbourhood, was pale and infiltrated. The lower part of the left lung was compressed, and there was slight general bronchitis. No other abnormality was found; a blood culture was negative, and no proof of general septicæmia could be adduced.

The temperature throughout the illness never exceeded 102°, and was of a mild septic type; just before death occurred it dropped suddenly.

Cases of infarction of the spleen are common enough. Those who make a practice of attending regularly in the post-mortem room will be familiar with them, not only in cases of pyæmia or of infective endocarditis, but also in persons dying from some quite independent malady, where they are presumably the relic of some long-forgotten 'pain under the heart.' Sometimes, indeed, the spleen is seen to be covered, as this one was, with a thick layer of fibrin, and to be densely adherent to the diaphragm and abdominal parietes. But it is very rarely indeed that the spleen, unless a malarial one, is found to have ruptured spontaneously, and to have killed its owner by hæmorrhage. It is on account of the extreme rarity of this accident, in contrast with the comparative commonness of splenic infarction, that this case is recorded. It must be emphasized, moreover, that apparently the spleen was inflamed for some hours, possibly for some days, before rupture occurred.

I have to thank Lieutenant-Colonel Toogood for his courtesy in permitting me to publish the case.

BILATERAL OVARIAN DERMOID CYSTS SIMULATING RENAL COLIC.

By C. H. FAGGE, London.

Nurse H., age 27, complained one evening of dull 'stomach-ache,' which she had endeavoured to treat with castor oil, but without success. The history she gave was that she had had scarlet fever in childhood, but no other illness of importance; the recent pain had been at first a diffuse abdominal pain; she had taken a dose of oil, and then, as the first dose made her sick, she had taken another.

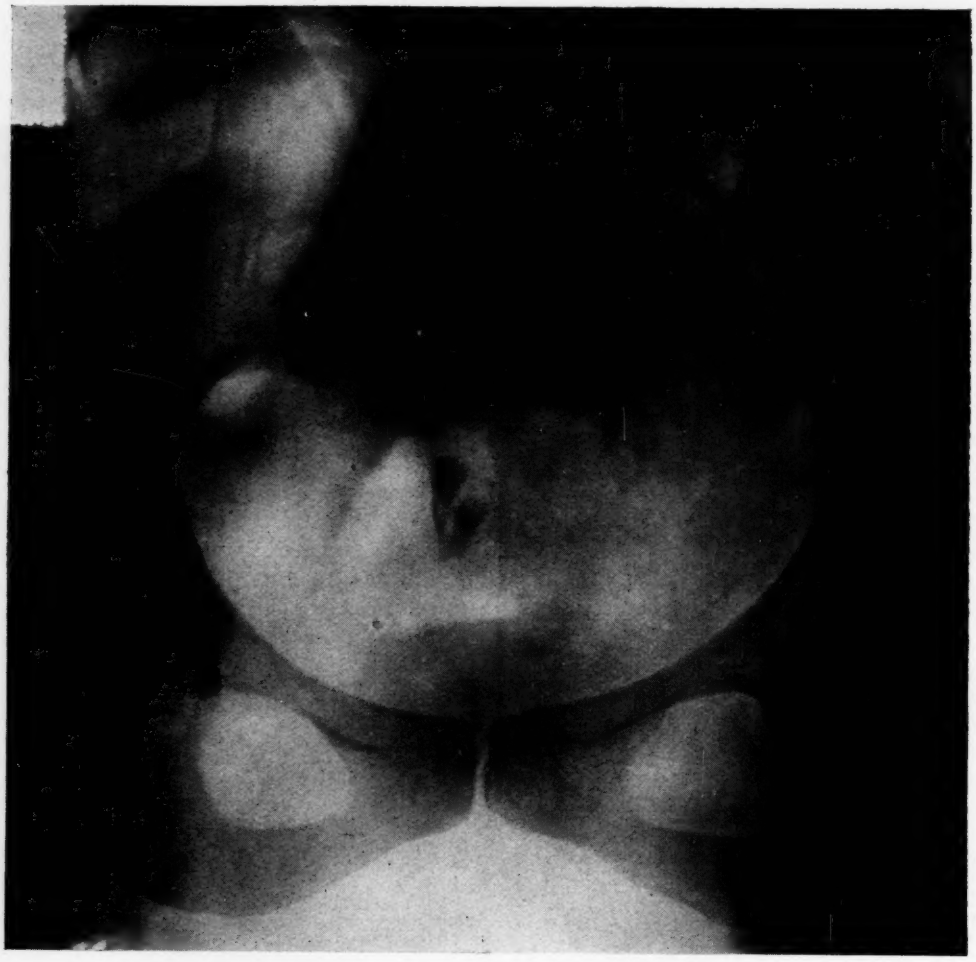


Fig. 408.—Radiogram showing two teeth in ovarian dermoid cyst.

The medical man who first saw her regarded the case as one of so-called gastritis, and gave her a little chlorodyne; this alleviated her pain, and she slept fairly well. By the following evening, however, the pain had returned; it originated in the left loin, radiated to the left subcostal region, round the waist, and (a little later) towards the groin. It was of a colicky nature, and accompanied by nausea, though not by actual vomiting. No tumour could be felt in the renal region, or elsewhere, and the urine was reported by the sister of the nurses' sick-room to be normal upon chemical examination.

Renal colic due to calculus was suspected, and a radiogram was taken, which cleared up the diagnosis (*Fig.* 408). Two teeth were to be seen very plainly at the level of the pelvic inlet ; the root-canals can be distinctly made out in the original plate. Since the patient had not swallowed any teeth, it was evident that she was suffering from an ovarian dermoid cyst. Moreover, radiograms of the kidneys showed no evidence of calculi, so that the cyst was probably the cause of the symptoms, and not merely incidental.

The patient was transferred to a surgical ward. Whilst awaiting the visit of the surgeon in charge, a sudden change occurred in her condition : she began to vomit violently, and became distended and tympanitic ; in short, she showed not only signs of pressure upon the ureter, but of intestinal obstruction. It should be remarked that prior to this attack of obstruction, she had suddenly passed an unusually large quantity of urine, suggesting that the renal symptoms which had predominated at the early stage of her illness were due to hydronephrosis—closed at first, and finally open.

In view of the sudden change in the patient's condition, laparotomy was performed with the least possible delay ; it was found that there were two ovarian cysts, firmly impacted in the pelvic brim. Both were multilocular, and contained hair and pultaceous matter of the usual kind ; the teeth were found in the right cyst, whilst the left cyst had evidently pressed upon the pelvic colon and caused the obstructive symptoms. The left ureter showed no external sign of obstruction, though some hours had elapsed since the discharge of urine, so that it is not surprising that no such sign was seen, and the absence of any such indication in no way controverts the diagnosis of hydronephrosis. The pelvic colon showed the usual signs of recent moderate obstruction. Both cysts were excised. No trace of ovarian substance or of supernumerary ovaries could be seen macroscopically. Recovery was uneventful.

The further history of the case is not at present ascertainable, but it seems probable that complete amenorrhœa will soon set in, with all the ordinary train of physical and psychical changes, for the girl's appearance, prior to operation, was such as to suggest that her supply of ovarian internal secretion had long been deficient.

The main interest of the case centres in the unusually complete simulation of renal trouble at the start, and then the sudden transformation into a case of intestinal obstruction ; also, in the rapid and certain aid to diagnosis afforded by the x rays.

The teeth in the right dermoid were about as long and as thick as adult canines ; the crowns were slightly flattened, and showed several little cingulæ near the top ; each tooth had a single root, though the apex of one of them was a little bent to one side. No trace of dental or bony matter was found in either cyst beyond these two teeth, though there were a few partially-calcified areas in the débris.

REVIEWS AND NOTICES OF BOOKS.

The Breast: Its Anomalies, its Diseases, and their Treatment. By JOHN B. DEAVER, M.D., LL.D. and J. MCFARLAND, M.D., assisted by J. LEON HERMAN M.D. Large 8vo. Pp. 724 + vii, with 8 coloured plates and 277 illustrations. London: Wm. Heinemann (Medical Books) Ltd. 40s. net.

THIS is a substantial volume of 700 large pages, indispensable to every serious student of its subject. The authors' names raise expectations which are not disappointed. In compiling the work their search through the literature of the subject has been exhaustive. An outstanding feature of the book is the catholicity, completeness, and fairness of its bibliography. Reference will be found to all important papers in English, French, or German. Brief summaries of many of these are given. A striking fact emerges, namely, that nearly all the important contributions to the surgery of the breast are due to the English-speaking races. Were it not for Anglo-American work the surgery of breast cancer would still be in its infancy. In Germany, and even in France, it still lags behind. Just before the war the leaders of French surgery, save for a few of the younger school, were of opinion that removal of the great pectoral muscle was an unnecessary and crippling procedure. Many of them denied the occurrence of cancerous infection of this muscle from the adjoining breast.

Those who wish to form their own opinions from a study of the evidence will be grateful for the fair-minded way in which opposing views are presented, and for the very numerous detailed case-records from the literature. The more cursory student may, perhaps, feel that amid its wealth of detail the book is lacking in clear and strong outlines. He will be better served by a smaller and more compact account of the diseases of the breast; but even he may well find the book indispensable for purposes of reference on particular points of interest.

The volume opens with a section of 160 pages on the evolution and involution of the breast, its surgical anatomy, and its congenital and acquired anomalies. Over 100 pages are devoted to the mammary anomalies, and 66 illustrations of classical or personal cases are given in this section. The nature of the subject demands its treatment by detailed case records, and the section is a masterpiece of historical research among the curiosities of pathology. For instance, a table of 240 cases of mammary hypertrophy, with detailed references and case summaries, is to be found on pp. 120–138. Upon breast abnormalities the book at once takes a position of unrivalled authority. A chapter on wounds and injuries of the breast follows.

The account of carcinoma, to which most readers will turn, occupies 160 pages. It opens with a confession of our ignorance of the cause and nature of cancer in spite of the labours of a generation. This refreshing note of frankness, so essential to the progress of knowledge and so rarely met with in medical works, is conspicuous throughout the book, and the reader responds to it each time with a renewal of confidence and interest.

The authors believe that cancer invariably "begins as a local disturbance at a minute focus, and spreads." Thus they do not recognize the multicentric or diffuse carcinoma which lights up at the same time over a considerable area of the breast. This event is exceptional, but that it occurs is shown by the fact that such a cancer when first detected may take the anatomical sector-shape of the lobe or group of lobes in which it originated.

The authors rightly pillory the ridiculous multiplication of names for so-called varieties of cancer, by giving a list of over fifty of these names. They prefer to insist on unity in multiplicity rather than upon multiplicity in unity, and again the reader breathes a sigh of relief and gratitude. The authors describe six distinct varieties of carcinoma. Curiously, they give no definite account of columnar-celled or duct cancer, a form which in America appears to be included along with acinous carcinoma—a confusion of two varieties often distinct histologically and in some cases clinically. The authors rightly insist that the expressions scirrhus and encephaloid as applied to cancer are clinical, not pathological, and that different sections of the same tumour may show respectively a fibrotic and a cellular form of growth.

The authors thus sum up their beliefs on the dissemination of cancer:—

> "While a number of steps in the progress of dissemination need further investigation, metastasis may for all practical purposes be attributed either to embolism (blood- or lymph-vascular) or to the process which Handley terms 'permeation.'"

They proceed to show that blood has great power of destroying cancer emboli. A full account of the permeation theory follows, and appears to mark the definite acceptance of this theory by American opinion. It is a great gain that agreement has been reached upon the mode of dissemination of cancer, for the surgery of the disease is thereby for the first time placed upon a rational

basis, and an instrument of criticism is provided to decide or reconcile the conflicting claims of various methods of operation.

The chapter on prognosis is the fullest and most scholarly discussion of a difficult subject with which we are acquainted, and is an admirable example of clinical research. We note one important omission. Among the few almost certain elements in prognosis is the development of evidence of internal metastases, when a period of under a year can be put to the patient's life. The authors admit the impossibility of prognosis for any individual case :—

> "We should confine ourselves in prognosing any given case of carcinoma of the breast to the average result obtained in that class of patients to which we believe, from the results of our physical examination, the one under consideration belongs. It has been demonstrated that 80 per cent of patients in whom the disease is confined to the breast as proved by both macroscopic and microscopic examinations of the tissues adjacent to this organ, are permanently 'cured' of their disease by the radical operation. Therefore, a patient presenting a small movable mass localized to the breast, can be assured that four out of five cases of a similar nature are cured by operation. When the axillary lymph nodes are palpably enlarged as the result of metastases, the chances of operative cure are at once diminished to *one in five*."

The question of palliative operations is fully discussed. The authors fix a five-year limit after operation as the period after which recurrence, though still possible, is unlikely.

As to the influence of the mode of operation on prognosis :—

> "There can be no question at this time of the comparative values of the Halsted and similar radical methods of breast amputation, and the less radical procedures, in those cases which are considered operable.
>
> "It is difficult, if not impossible, to estimate the influence of the various modifications of the original Halsted technique on the prognosis of mammary carcinoma. Extensive removal of the skin with more extensive removal of the deep fascia, as advised by Handley, undoubtedly has served to decrease both local and regional recurrences. We believe that the prognostic effect of preserving the pectoralis major muscle is an evil one, and find our view substantiated by Vanvert."

The authors rightly emphasize the immense impetus given by Halsted to the surgery of the breast, and they still consider his operation as the standard one, with such modifications as are rendered necessary by subsequent research. An English surgeon might here interpolate a claim for the contemporary operation of Stiles and Watson Cheyne, which, in its insistence on the necessity of undermining the flaps extensively, was definitely superior to the procedure of Halsted.

It is possible without violating pathological requirements to devise various methods of removing a breast cancer, and the authors select for description the methods of Halsted, McFarland, Handley, Kocher, Rodman, Stewart Murphy, Dawbarn, Meyer, Tansini, Warren, and Jackson. The plastic methods, such as that of Tansini, are rightly condemned. Our complaint here is that the various methods are not submitted to rigid pathological criticism, and the reader is practically left to choose between them. For instance, the indifference of Kocher to the precise location of the tumour in the breast is not commented upon. He would apparently perform the same operation whether the growth is situated under the nipple or at the axillary edge.

A welcome chapter is that by Dr. George E. Pfahler upon the non-operative treatment of cancer of the breast. The scope of these methods is rightly limited to cases unsuitable for operative treatment. The encouraging nature of the results attained by x rays and radium is fairly presented. It is pointed out that, in dealing with such large areas as are affected in breast cancer, x rays usually possess the advantage over radium.

In the chapter on Paget's disease, the authors give what is one of the best accounts of the histology of the condition, evidently from careful first-hand observation. As to the nature of the disease, they reserve judgement. The references to the literature of this affection occupy seven pages at the end of the chapter, an illustration of the authors' conscientious work, and of the perennial controversy which centres around the pathogenesis of the disease.

Our chief criticism of the book, and perhaps of the present tendencies of thought among surgeons generally, is the authors' expressed willingness to trust for guidance to the comparative statistical results of different methods of operation rather than to the light of accurate knowledge based upon pathological research. They say, for instance, "There are many phases of the problem of metastasis that cannot be considered in a treatise of this kind, but they are of little practical moment"—a sentence which suggests, however erroneously, that they turn from the complex problems of dissemination with a gesture of intellectual fatigue. The complement of the last-quoted words is found on p. 603, where the authors say : "Whether or not there be a *best* routine operation for mammary carcinoma remains to be shown. The only way to settle the question is to ascertain the comparative end-results in large series of cases after removal of the breast by different methods." To illustrate our point of disagreement, let us take a geographical illustration. If it is required to find the best route between two cities for a railway, the method adopted is not to follow the sinuous sheep-tracks of hoary tradition, or even the broad highways of recent years, which represent the survival and development of the fittest of these tracks. The modern method is to survey the country and ascertain the levels and the local conditions. Only then is it possible to

reduce infinite possibilities of devious error to a single best, or to a choice between a few equally good alternatives. The surgeon must look to the pathologist, and not to statistical comparisons of end-results, riddled with sources of fallacy, for the guidance which the railway engineer gets from the surveyor. If the English surgeon has learnt from America to study and appreciate surgical workmanship and to reform a slipshod technique, his American colleagues may perhaps in their turn remember with advantage that first-hand pathological knowledge is the only safe guide for their skilful hands.

This review is necessarily incomplete, but we have said enough to persuade all serious students of breast surgery that they must possess the book.

Tumours of the Nervus Acusticus and the Syndrome of the Cerebellopontile Angle. By HARVEY CUSHING, M.D. Harvard. Large 8vo. Pp. 296, with 262 illustrations. 1917. London and Philadelphia: W. B. Saunders Co. 21s. net.

PROFESSOR HARVEY CUSHING'S book is both a record of a great surgical advance and a model of how such a record should be made. Since the beginning of this century a miasma of depression has settled upon the field of neurological surgery, originating from an honest and fearless recognition of the fact that the end-results in the mass are bad. Nor is there any ray of hope for the victims of most intracranial tumours from an alternative method of treatment. The patient and splendid work of Cushing during the last fifteen years, as revealed in this book, has dispelled at least some portion of the cloud. It is not only the practical achievement of the reduction of an operative mortality from an average elsewhere and everywhere of 70 per cent to under 14 per cent in his own clinic that compels admiration; but, further, it is the picture presented of vision and courage in the face of overwhelming difficulties and disappointments, recognizing failures with fearless honesty, rectifying them with consummate judgement and skill, and finally achieving the triumph so modestly set forth in these pages.

Beginning with a historical review of the earliest records of these cases—among which the most notable are those of John Bell in 1830 and Jean Cruveilhier in 1835—he traces the progress of knowledge through the differentiation between supra and infra-tentorial tumours; to the further subdivision into extracerebellar and intracerebellar lesions; and finally to the stage of recognition where tumours of the cerebellopontile angle assume a clinical identity. At this stage his own work begins, and from the nebular tumescence of the cerebello-pontile angle there now emerges the precisely formulated conception of 'tumours of the nervus acusticus,' which possess a unique histological structure, are constant in their anatomical relations, produce a sequence of clinical signs and symptoms of unmistakably clear significance, and are amenable to a modified surgical procedure that transcends through its success all previous endeavours in this region.

The terms 'acoustic tumour' or 'acoustic fibro-neuroma' have been deliberately chosen by the author in preference to any of the other twenty-three names already suggested by other writers (p. 195) as most appropriate to the cellular structure of the growths. This structure is composed of two main sorts of tissue—a dense fibrous tissue whose oval nuclei tend to be grouped in a "characteristic palisade arrangement," and "a loose areolar tissue possessing some of the architectural characteristics of a glioma." "The tumours are specific for the acusticus, and should not be confused with other growths arising in the cerebellopontile angle." Such a fixity of structure of tumours within the substance of the nerve, and of their origin from the distal portion of the nerve within the auditory canal, is in accordance with Sternberg's view that they are of embryonal origin—a view that receives additional support from a consideration of the mode of development of the eighth nerve.

Their anatomical relationships need the careful consideration that Cushing has bestowed upon them, so that an intelligent forecast of what symptoms may be expected from their presence can be made, and a right understanding of their significance may be achieved. Of immediate surgical importance is the fact that they are situated beneath the arachnoid, which may distend enormously with fluid over their surface, giving the appearance at operation of a large cyst. Unless this has been sufficiently appreciated, the cyst may be punctured in the belief that it is the lesion sought for, whilst the underlying tumour remains undiscovered.

The symptoms and signs are elaborated by the author with a wealth of detail that provides a mine of information, prevented from overwhelming the reader with its encyclopædic load by the clarity and precision of his writing. His general conclusions alone can find space in a review. He states (p. 176) that the "symptomatic progress of the acoustic tumour occurs more or less in the following stages: (1) The auditory and labyrinthine manifestations; (2) The occipito-frontal pains, with sub-occipital discomforts; (3) The incoordination and instability of cerebellar origin; (4) The evidences of involvement of adjacent cerebral nerves; (5) The indications of an increase in intracranial tension, with a choked disc and its consequences; (6) Dysarthria, dysphagia, and finally cerebellar crises and respiratory difficulties." Further (p. 152): "The chronology of symptoms makes it clear that the clinical diagnosis of an acoustic tumour can be made with reasonable assurance *only when auditory symptoms precede* the evidences of involvement of other structures in the cerebellopontile angle. Hence, when the inaugural symptoms of a growth obviously situated in the angle have another sequence, *with secondary acoustic symptoms*, the diagnosis must remain uncertain until the lesion is exposed." The large series of cases successfully diagnosed

and submitted to operation affords the best proof of the validity of his conclusions. It is clearly of great practical value that the sequence of the symptoms should be so constant, and that the earliest should arise in the special sense organ to which the affected nerve is distributed.

Once more the importance of early diagnosis is urged, and by the pen of the writer whose work has done so much to render it possible. Not the least tragic of his experiences has been the late stage of the disease which many of the patients had reached before being brought to him. Blind and bedridden as many of them were, yet the lease of life was frequently renewed at his hands for a period of from three to seven years. What possibilities are unfolded for successful surgical treatment when cases can be submitted to it in the earlier stages of the disease whose recognition has now become possible through his labours!

The author's methods of operation—which have done so much to standardize the surgery of the cerebellar fossa—are again described in full; his important modification of the enucleation of the contents of the tumour from within its capsule being the essential feature of his new work.

"Middle ear," twice repeated on p. 208, is clearly a misprint for "internal ear," and on p. 181 and p. 190 S. G. Shattock's name is misspelt 'Shattuck.' Such trivial comments as these are a measure of the difficulty of finding any blemish in so splendid a book. Physicians and surgeons alike will find refreshment and reward by reading it.

Surgical Therapeutics and Operative Technique. By E. Doyen. English translation by H. Spencer-Browne, M.B. Cantab., etc.; Elève de l'Institut Pasteur; Physicien et Chef de Clinique de l'Institut Doyen. In 3 vols., large 8vo, with about 3000 illustrations. 1917. London: Baillière, Tindall & Cox. 25s. net each volume.

This English edition is taken from the material from which the second French edition will be compiled, and contains the latest developments in war surgery and surgical treatment in general. Only the first two volumes are ready as yet.

Vol. I contains an Introduction, which deals with the state of surgical practice at the beginning of the twentieth century, with surgical technique, and with the duties and rights of the surgeon. Emphasis is laid on the importance of anatomical knowledge, and on the importance of every surgeon being his own diagnostician, and not merely an operator. The surgeon is encouraged to remember that surgery is not only a science but also an art, and that it is by the excellence of his technique that the artist is revealed. The remainder of Vol. I is divided into two parts, the first dealing with general surgical technique, and the second with the regional surgery of the head.

Part I gives a short account of the arrangements and working of the author's Surgical Institute in Paris, and a much more detailed description of the operating department, including the general management of patients before, at, and after operation, the aseptic and antiseptic methods employed, and anæsthetization.

'Attached services' comprise laboratories for diagnostic research and teaching purposes; and the many-sided character of the Institut Doyen is appreciated on reading the short sketch of these, which include laboratories of bacteriology, serotherapy, chemistry, histology, radioscopy, photography, and cinematography.

There is an interesting chapter on hæmostasis, with plates taken from Serrig's atlas, and a criticism of the methods employed by the older surgeons, which is followed by a description of the author's own instruments and devices for dealing with hæmorrhage. Doyen, besides being a skilful operator, was a mechanical genius, and designed most of his surgical instruments; the somewhat formidable size of many of these is accounted for by his method of operating, which was rapid, and largely a combination of enucleation and crushing. Doyen emphasizes over and over again the importance of operating rapidly; indeed, he says, so far as the patient is concerned, 'time is life'; and for a surgeon of his almost uncanny dexterity such a maxim was undoubtedly a very proper one. This eye-on-the-clock method, however, will hardly find favour with present-day surgeons, who rather take the view that dainty handling and an artistic finish require time and produce the more gratifying results. Doyen clearly recognized the avascular layer which surrounds all organs, in which the enucleating finger or instrument produces the minimum of bleeding, and across which only definite and well-marked vessels run, easy to see and clip; he illustrates this very plainly in the section dealing with the thyroid in Vol. II.

The author's therapeutic innovations are also described, and a brief account is given of his anti-neoplastic vaccine and of mycolysine—a preparation employed by him to prevent and combat acute infections.

This part on general surgical technique concludes with an excellent and full account and criticism of the various methods employed to destroy growths by heat and electro-coagulation. Doyen used a high-frequency current of low tension, the electrode being left in contact with the diseased tissue. He claims priority in the discovery of the deeper penetration by this method, and also of the selective nature of a temperature of 60° C. for pathological tissue. His experience with this form of treatment of carcinoma was a very happy one.

The section on regional surgery, as far as it has been published, occupies the last 140 pages of Vol. I and the whole 680 pages of Vol. II, and deals with the head, neck, thorax, and upper and lower extremities. The general plan adopted in each region is to give a short description of

the clinical characteristics of the disease under discussion, with the indications and contra-indications for operation, the surgical anatomy of the part, a plate depicting the instruments required, with a description of the same, and finally, a description of the operation itself, which is clearly and concisely divided into stages. Each operation is profusely illustrated with most excellent diagrams, which are one of the noticeable features of the book. Many classical, but defunct, operations are not mentioned. The operations are those used by Doyen and his staff, standardized so to speak, and permeated by his technique; where necessary, modifications, such as the experience of the author has led him to adopt to meet complications, are described.

There is a good section on the comparatively recent field of lung and heart surgery, for which Doyen has introduced several excellent instruments. Vascular surgery and blood transfusions are dealt with fully, and in a thoroughly up-to-date manner.

The plan and general treatment of the subject matter, in Vol. II particularly, is refreshingly original, and it is perhaps only what one would expect from a genius who not only constructed most of his instruments, formed a technique peculiarly his own, and introduced many original therapeutic remedies, but who devised many of the operations he performed, and altered most of the others to suit his own characteristic methods.

It was this originality of the author's work, and the great interest shown by the large number of visitors to his Institut in Paris, which led to a general desire for an English edition of his text-book; the French edition has already had a wide success abroad.

Collected Papers of the Mayo Clinic. Vol. IX, 1917. Edited by MRS. MELLISH. Pp. 886, with 331 illustrations. 1918. Philadelphia and London: W. B. Saunders Co. 28s. net.

THAT it should be possible to produce a volume similar in size and in the number of its contributors to those issued in former years, during the year when the United States entered the War, and at a time when the whole nation, and not last in this respect the medical profession, were making most thorough preparations to take their share in its burdens, says much for the enthusiasm and activity of the staff. While there are no papers definitely dealing with diseases or injuries of war, yet this event has clearly set its impress on the volume, in that it has led Dr. C. Mayo to write two papers on "War's Influence on Medicine," and "Medical Service in the United States Army."

The former, his presidential address to the American Medical Association, is a most delightful piece of reading, which shows that the writer is not only the master of wide information, but also has definite and broad views of the demands of national medicine in the States, and of the responsibilities and duties of those engaged in medicine. It will well repay careful reading by all those on this side who are interested in and giving much thought to the remodelling of medical education. While Dr. Mayo expresses in this first article a quite natural and justifiable pride in the accomplishments of his fellow-countrymen in showing that "man's power to control the elements was developed in America," he is under no delusions that their state is a perfect one: in pointing out in his second paper the benefits which the American nation may derive from active participation in the war, he writes: "Our nation is becoming soft, dissipated, and inefficient. . . . We make many laws, but obey few, and having an abhorrence of discipline, we discuss freedom." There is certainly no evidence of this decadence having spread to Rochester, Minn.

In reviewing the medical service in the United States Army, he enters a plea for higher rank for medical officers, and deplores the fact that the Surgeon-General is not a member of the War Council. "This is another of the conditions such as brought about the Mesopotamian failure," which on another page he stigmatizes as the "last atrocious medical failure"; this straight speaking should do good in helping us to realize the defects of our own system and the path along which reform should move.

Dr. L. B. Wilson contributes a complete review of the literature of trench foot, which should be most helpful to those likely to have to treat such cases in future campaigns.

The same author's paper on "Graduate Work in Medicine in the University of Minnesota" shows how the Clinic is tackling this most important question, and tells how in 1915 the Mayo foundation entered into a temporary agreement with the University of Minnesota for graduate work in pathology, medicine, and surgery, which was made permanent in 1917. It appears that the funds for this purpose have been handed over by the Mayo foundation to the control of the University, which indicates a very broad-minded attitude of the former and the wise policy of those responsible—without doubt the Mayo brothers—in thus devoting a large proportion of the earnings of their life-work to the benefit of medicine of the future. We could wish that post-graduate training, now becoming a very live issue in this country, could be directed by equally sage counsellors, for Dr. Wilson's views on "University ideals" are no less admirable than the "general plan" on which it is proposed to put them into execution.

Clinical papers occupy less of this than of former volumes, which fact may be due to the present pre-occupation of many of the staff with military affairs; of those which do appear, perhaps the most valuable is that by Dr. W. J. Mayo in which he deals with forty-two cases of diverticulitis of the colon treated by resection. We are not aware of any paper in which so large a number of operative experiences for this condition have been brought together. The problems and difficulties met with in the course of such operations are handled with the

resource and judgement which those of us who have long sat at his feet have learnt to expect from this writer.

Dr. W. W. Bissell's paper on pulmonary fat embolism thoroughly reviews the pathology of this condition, and is valuable in drawing attention to a post-operative complication which, in the author's opinion, is often confounded with shock from other causes.

Dr. D. C. Balfour discusses the conditions which may call for splenectomy, with a very full bibliography; this paper will carry weight in conjunction with the same writer's former papers on the surgery of the organ, which indicate that his experience has been exceptionally wide.

Of the purely scientific papers, that by Dr. MacCarty on "Cancer's Place in General Biology" is original in conception and most fascinating in suggestion; the cellular reactions are described, and illustrated by beautifully-drawn plates which illuminate the argument. The writer, perhaps wisely, makes no effort to explain why these changes take place.

In our former reviews of the Mayo Papers, we have taken the writers to task because we have held that some articles were scarcely worthy of the institution from which they emanated; those who had not had the unique privilege of visiting the Clinic would, we held, fail to gather from its publications the value of the work which it was really doing for medicine; we felt that its reputation must suffer, and that, from the greatest combined clinical and scientific institution which has been evolved by men still living, nothing but the best could be regarded as representative. To a large extent this criticism no longer holds good, for the first-mentioned papers by Dr. C. Mayo and Dr. Wilson, in mirroring the ideas and character of the institution, can only add to its laurels, and in themselves justify the issue of the Collected Papers.

Gunshot Fractures of the Extremities. By Joseph A. Blake, Lt.-Col. Medical Corps, U.S.A. 8vo. Pp. 136, with 40 illustrations. 1918. Paris: Masson et Cie. 4 fr.

This small book represents the results of practical experience during the present war. The methods of treatment of gunshot fractures represent on the whole that which has been lately in vogue in the British Army and which was described by Ogilvie in the last number of the British Journal of Surgery. The author does not accept Leriche's view of the desirability of the removal of loose fragments from comminuted fractures, but wisely insists on the value of these in regard to regeneration of the bone. He lays great stress upon the importance of maintaining the limbs in a position of physiological rest—that is, with semiflexion of the principal joints. He also urges that active traction by a weight and pulley is much more efficacious than passive traction by tying the limb to a splint. He recommends and illustrates what we consider to be an unnecessarily complicated system of suspension. In cases of severe fractures of the arm he advises a system of traction and suspension, without the use of rigid splints, and we think his arguments for this are quite sound. The sections on vicious union and non-union are too short to be of any practical value, and his reference to the use of inlay grafts gives a misleading impression that this is a satisfactory method of treating ununited gunshot fractures.

The book is a very valuable guide to the matter of which it treats, and it is a matter for regret that it has appeared so late in the war.

Local and Regional Anæsthesia. By Carroll W. Allen, M.D., New Orleans. Second edition. Pp. 674 + 14, with illustrations. 1918. Philadelphia and London: W. B. Saunders Co. 28s.

It is a pity that Dr. Allen's book on local and regional anæsthesia is so bulky. In these busy days, operating surgeons, for whom it would have most value, have little time and no inclination for reading lengthy dissertations. The historical presentation of the subject is interesting. The essence of the technical descriptions is of good quality, but is too highly diluted. The illustrations are excellent and useful, especially those borrowed from the works of Braun and Härtel. The syringe and attachments recommended by Dr. Allen are inferior to those used by most British surgeons who use local anæsthesia extensively. The syringe is too small, and there is no rapidly-locking arrangement which prevents the nozzle being forced off. The admixture of $\frac{1}{4}$ per cent potassium sulphate with the anæsthetizing solution, which has been found by other surgeons to enhance and prolong the anæsthesia, has apparently not found favour with Dr. Allen. We join with him in recommending the study of the anatomy of the nervous supply of parts which are to be operated on under local anæsthesia. Failure is frequently due to want of this anatomical knowledge. A concise description in English of the technique necessary for success is very desirable.

The Treatment of Infected Wounds. By A. Carrel and G. Dehelly. Second English edition. 81 figures and 6 plates. 1918. London: Baillière, Tindall & Cox. 6s. net.

The only defect in the original edition of this classic work was the omission to provide sufficient information as to the results obtained by the treatment now so well known and so widely practised under the name of the Carrel-Dakin method. In the edition before us this has been remedied, and the reader will also find information as to the results obtained by the method in the treatment of wounds, fractures, and joint injuries that are not of recent origin. What will be the exact scope of the method after the war it is of course impossible to say; but the book is more than welcome, if only as a memorial of a most brilliant and valuable research planned under circumstances of great stress and brought to achievement within a phenomenally short time.

Applied Anatomy: The Construction of the Human Body considered in relation to its Functions, Diseases, and Injuries. By GWILYM G. DAVIS, M.D., M.R.C.S., Professor of Orthopædic Surgery in the University of Pennsylvania. Fifth edition. Pp. 630, illustrations 631, many in colour. 1918. Philadelphia and London: J. B. Lippincott Co. 30s. net.

THIS is the fifth edition of Professor Davis's sumptuous book. It contains a wealth of illustrations, many of them in colour, by Mr. Erwin F. Faber. The profusion of illustration is realized when one finds that there are 631 pictures in 630 pages.

The book is obviously the work of a trained teacher. The language is terse, and always clear. The anatomical facts are presented to show their value in relation to the art of surgery. The book is essentially practical. It is sound anatomy, and happily is written in the old terminology, a point which should enhance its value to students. One is amused to see the old error about the angle of Ludovicus (Louis), this cropping up in several places as the 'angle of Ludwig.'

Development is introduced to explain anomalies and deformities. The embryological references are sometimes misleading, or too brief to be sufficiently explanatory. The vexed question of the development of the sternum is too summarily dismissed; and in relation to the subject of imperforate anus, there is an inadequate account of the development of the cloaca, etc. The account of the development of the genito-urinary system is rather superficial.

The subject is treated regionally, and the best sections are those on the neck, thorax, and abdomen. There is an excellent and accurate account of the abdomen, and of hernia, with very good illustrations. It is in relation particularly to the limbs that one is disappointed that a Professor of Orthopædic Surgery should leave so much that is of prime importance unsaid. While there are many excellent paragraphs in the description of the upper limb—notably in the sections dealing with dislocations and fractures in the region of the shoulder—the account of the joints, tendons, and peripheral nerves is weak. In the account of the lower limb, similarly, there is a very sketchy account of the joints and nerves; and the deformities of the foot are treated in a perfunctory manner. One must draw attention particularly to the almost complete silence of the author on the subject of the semilunar cartilages of the knee-joint. No account is given of any operation for their removal. The picture of the knee-joint on page 536 shows the tendon of the biceps flexor cruris passing apparently *under* the long external lateral ligament.

The illustrations as a rule are excellent. There have rarely been produced more vivid and lucid drawings than those of the muscles shown in this book. The pictures of the neck, thorax, and abdomen are also excellently reproduced. As an appendix a number of valuable illustrations are given of frozen sections through the trunk and limbs.

The author is fully justified in the statement made in the preface to the effect that the book is suggestive rather than absolute—and in his hope that it will appeal to the practising physician and surgeon as well as to the student. After a careful perusal of the work, one has every confidence in recommending it to the student in anatomy and surgery. It will be of great service also to the demonstrator of anatomy and young teacher of surgery, from its value in pointing incisively the applicability of anatomical data to surgical problems. For the operating surgeon it has less value. He will naturally appeal either to the cadaver itself or to a systematic textbook of anatomy for the information he seeks. The modern military orthopædic surgeon will not find here the detail or accuracy needed to enable him to perform operations on tendons, joints, or peripheral nerves.

Military Surgery. By DUNLOP PEARCE PENHALLOW, S.B., M.D. Harvard. Second edition. Pp. 555. 1918. London: Henry Frowde and Hodder & Stoughton. 21s. net.

THE rapid changes in military surgery have necessitated many alterations of view, and it is therefore not surprising that the author has found it necessary to issue another edition. When dealing with the previous edition, we called attention to some of the more important omissions. In the volume before us these have been to a great extent supplied, and a much more complete picture is presented of the state of military surgery, with a tendency to dwell upon treatment in this country, rather than that in the forward areas of the war. Some sections are rather inadequately treated, notably that dealing with injuries to blood-vessels, in which the importance of the decision whether ligature or arteriorrhaphy shall be employed in certain cases does not appear to be recognized. Possibly this is because so little has appeared upon this subject in English surgical literature as contrasted with that of the allied and enemy forces. The important subjects of fractures of bones and wounds of joints receive extended notice, and due stress is laid upon the importance of complete primary treatment if a good result is to be obtained.

Surgical Treatment: A Practical Treatise on the Therapy of Surgical Diseases, for the use of Practitioners and Students of Surgery. By JAMES PETER WARBASSE, M.D., F.A.C.S. In three large 8vo volumes and separate desk index volume. Vol. I. Pp. 947, illustrations 691. 1918. Philadelphia and London: W. B. Saunders Co. £6 6s. per set.

THIS work, dealing with surgical treatment in three large well-illustrated volumes, is one of great importance. It combines the advantages of an expensive *System* of encyclopædic scope with those of a book written by a single author. The present volume deals with general principles, anæsthesia, operative technique, surgical infections, blood-vessels, bones, joints, muscles, and

nerves. It includes a description of all the most important surgical operations, together with the preparatory and after treatment suitable for each. The descriptive matter and illustrations are extremely clear, and for reference purposes every important method of surgical treatment is easily looked up.

Naturally the author of such a book, being anxious to represent every method, is apt to overlook the necessity for a critical examination of each; for example, in the operation of arthroplasty for knee-joint ankylosis, the procedure is described very much as that for a bunion, with the mere remark that the operation on the knee "gives most gratifying results."

The preliminary articles on general principles and operative technique are good and complete; that on anæsthesia being a very useful presentation of various modern methods. The description of intratracheal anæsthesia is, we think, the weakest part of this section, the value of the procedure in oral surgery not being given due weight. Spinal anæsthesia and its various modifications, on the other hand, are dealt with at disproportionate length. The articles on wound treatment and infections are brought into line with recent work by the inclusion of the Carrel-Dakin and other methods of war-wound treatment. Direct transfusion of blood is well and fully described, together with both the modern operations for the suture of blood-vessels and the more classical operations for ligature of the main trunks.

The chapters on fractures and bone operations are full of valuable information, although here again, for the sake of completeness, methods are included which might better have been left out—such, for example, as the so-called extension of the fractured femur combined with the use of a long Liston splint. Albee's methods of bone-grafting are given due prominence, together with various modern methods of open treatment of fractures. But the general principles of the treatment of fractures by extension methods are neither clearly appreciated nor adequately described, whilst a great number of odd methods are illustrated.

The book is, however, of the greatest possible value as a work of reference, containing, as it does, a great wealth of information and illustrations.

Burns and their Treatment, including Dermatitis from High Explosives. By J. M. H. Macleod, M.A., M.D. Small 8vo. Pp. 176, illustrated. 1918. London: Henry Frowde and Hodder & Stoughton. 6s. net.

The direct outcome of war experience, and the result of special study of the subject—including dermatitis from high explosives—this work appeals to readers by reason of its brevity, clarity of exposition, and utility. The author has sifted the literature of the subject thoroughly, and has presented not only the experience and apparatus of others, but his own practice and advice. Each section of the book deals in a plain matter-of-fact way with its subject matter, and carries conviction. There is a very good index, and the references are detailed and complete, so that in addition to its practical side, material for research work is provided. It is therefore from all points of view eminently useful.

War Wounds of the Lung: Notes on their Surgical Treatment at the Front. By Pierre Duval. English translation. 1918. Bristol: John Wright & Sons Ltd. 8s. 6d. net.

Pierre Duval was among the first to recognize that gunshot wounds of the lung should be treated by the same energetic measures as were being applied to gunshot wounds of other parts of the body, and that without such active intervention it would be impossible to lower materially the high mortality—due especially to infection—that was occurring in these cases. His attitude is expressed in the following paragraph: "It is the first principle in war surgery to prevent infection of wounds, and the only method of preventing sepsis in gunshot wounds is to operate on them, to remove all foreign bodies, and to excise as far as possible all necrotic tissue. It is only logical to think that the really effective treatment of infection in the lung, and of its usual complication, infection of the pleura, is preventive treatment by removal of foreign bodies and direct treatment of the lung wound." (p. 46 of the English translation).

Duval published *Les Plaies de Guerre du Poumon* in 1917, and this has now been translated into English. The book consists of some 100 pages and a few instructive illustrations. It is clearly and concisely written, and is devoid of all superfluous matter. The facts and the deductions based on these facts are set out in logical order and in a most straightforward and convincing manner. The English translation, the type, and the printing are all three excellent. The book is undoubtedly one which should be read by all who have to treat lung injuries, whether in the field or at home, as a knowledge of the matter contained therein is essential to success.

Commozione Cerebrospinale. By Dott. F. Pedrazzini. Small 8vo. Pp. 170, with 13 illustrations. 1918. Milan: Ulrico Hoepli. L. 3.50 net.

This little book emphasizes the reality of cerebrospinal lesions following concussion. The physics of the skull and vertebral column are first considered, then the compensatory mechanism provided by the elasticity of the spinal dural sac, the compressibility of the perimeningeal space in the vertebral column, and the slight compressibility of the brain and cord. These factors afford a large degree of protection; but when the force is applied instantaneously, there may not be

time for their action. Then the force will be transmitted by the incompressible cerebrospinal fluid direct to the compressible cerebrospinal matter. Experiments showed that hæmorrhages might occur in most parts of the brain, but especially in the pons and medulla, while in the cord the principal effects of spinal concussion were systemic degeneration and circumscribed foci of softening. After the examination from the literature of a number of cases of post-traumatic paralyses, the same principles are applied to the question of shell-shock. In the author's words: "In the neighbourhood of the explosion of large projectiles the pressure of the atmosphere on the surface of the body compresses the thoracic and abdominal cavities and the soft parts of the neck, and causes a reduction in size of the large veins and of the auricle, and a sudden obstruction to the returning flow of the blood. This gives rise to a sharp shock within the cranio-vertebral cavity, due to regurgitation of blood, with variations in the capacity of the elastic dural sac and of the volume of its contents, and consequently the production of waves of pressure and movements of the liquid in the arachnoid reservoir, analogous to those caused by traumatic deformations within the limits of the elasticity of the skull and vertebral column." Lumbar puncture should be used in these cases as a means of treatment as well as diagnosis.

The book is a serious contribution, based on experimental and clinical evidence, to a subject of general interest in these days.

Lessons from the Enemy (Medical War Manual, No. 5). By JOHN R. MCDILL, M.D., Major M.R.C., U.S. Army. 8vo. Pp. 262 + xvii, illustrated. 1918. Philadelphia and New York: Lea & Febiger. 6s. net.

IN a philosophic foreword, the author gives a bird's-eye view of the World War and of the part played therein by the medical profession. There follows a description of the German medico-military organization, ranging from the rank and pay of medical officers, to the equipment of hospitals, hospital trains, and base hospitals. In the treatment of gunshot wounds he declares himself an advocate of the Carrel-Dakin method, and gives an account of the German equivalent or imitation thereof. Concluding chapters deal with volunteer nursing under the Red Cross, re-education of the 'war-disabled,' orthopædic hospitals and workshops, and finally with artificial limbs. It may be confidently stated that within a small compass this book contains a quantity of information which is not easily obtainable from other sources.

Principles of Surgical Nursing: A Guide to Modern Surgical Technique. By FREDERICK C. WARNSHUIS, M.D., F.A.C.S. Large 8vo. Pp. 277, with 255 illustrations. 1918. Philadelphia and London: W. B. Saunders Co. 12s. net.

THIS small book is a successful attempt to give detailed practical directions as to a nurse's duties in the operating theatre, at private houses, and in the wards.

The author has embodied the essential details of everyday practice, with a sufficient amount of theoretical explanation to justify the same. Such a book is always open to the criticism that by laying down too great an amount of detail a system is taught which does not represent the practice of more than a single individual. But it is probably better for practical purposes to describe accurately the practice of one man, than be content with vaguely outlining principles which all are agreed upon. The book certainly inculcates the idea of a keen surgical conscience, and this principle is perhaps the most important that can be taught by such a work.

We think that no good purpose would be served by criticizing details of the author's technique, because as has already been stated this is largely a matter of individual practice. With recent experiences of war surgery vividly in our minds, we think the greatest need of this book is to describe methods of dealing with emergencies, and the organization of nursing of numbers of septic cases. The author contents himself with describing the technique of the operating room, post-operative emergencies, anæsthesia, plaster-of-Paris splints, the operation for appendicitis, and a few other less important details. It is doubtful whether the great wealth of photographic illustrations adds very much to the value of the book.

The Treatment of War Wounds. By W. W. KEEN, M.D., LL.D. Second edition. 8vo. Pp. 276, with 53 illustrations. 1918. Philadelphia and London: W. B. Saunders Co. 8s. 6d. net.

THE best testimony to the value of this work is the fact that its first edition has been exhausted in six months. This has been due no doubt to the great reputation of its author. The present edition has been largely re-written, in order to deal with the subjects of shock, the Carrel-Dakin and other methods of wound treatment, fractures, tetanus, wounds of the head, chest, and joints, and gas gangrene. The book is so short, and consists so largely of abstracts and summaries, that it cannot be regarded as more than a brief *résumé* of recent work. It is to be regretted that such an inaccurate picture as *Fig.* 21 should ever have been drawn and reproduced. It represents a Balkan splint so arranged that the thigh sling could never remain in the position indicated.